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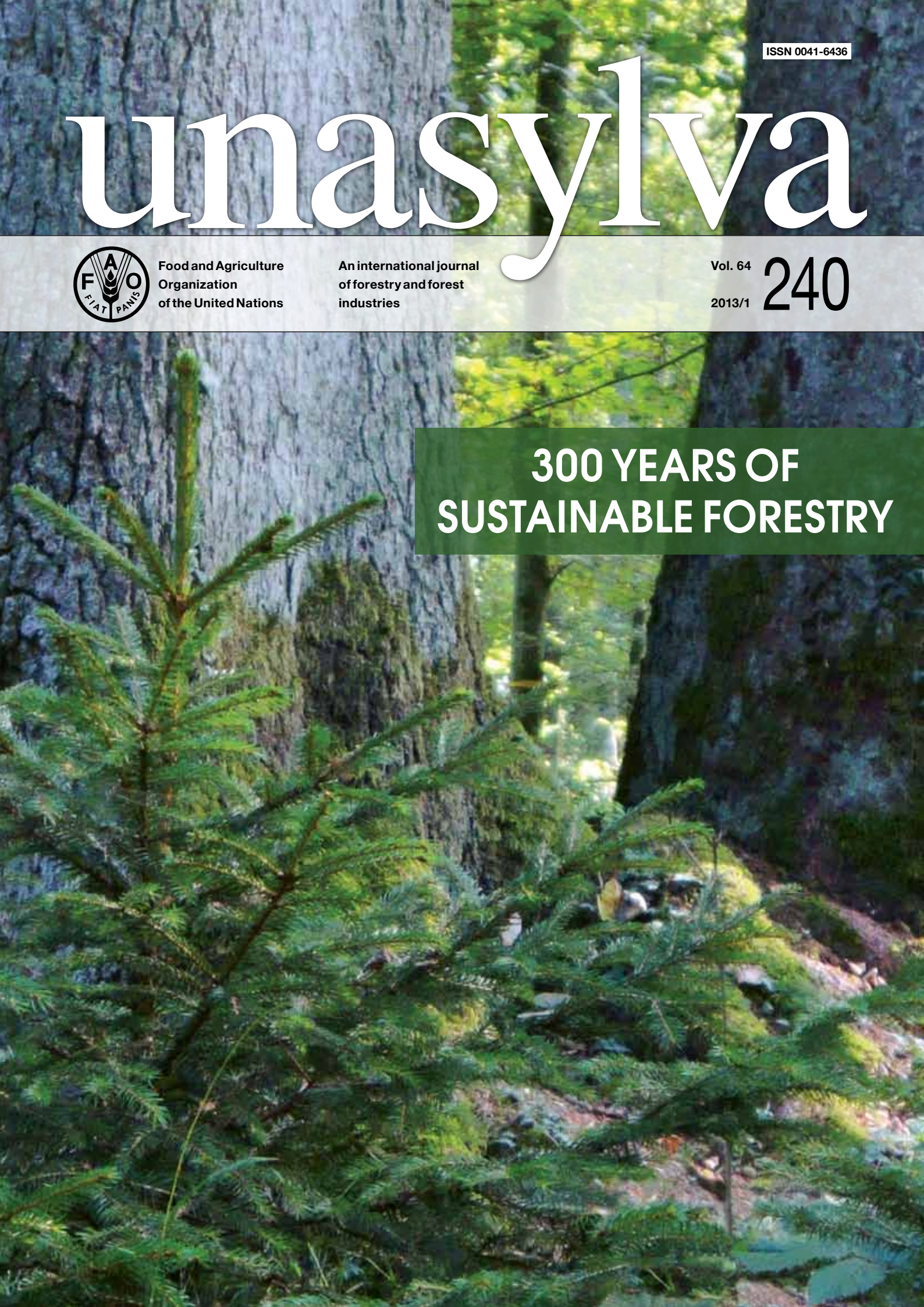

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Cover: Close-to-nature managed forest in Basadingen, Canton of Thurgau, Switzerland. This young, naturally regenerated spruce will grow slowly for decades in the "waiting room" until parent trees are harvested. In the additional light it will then develop its crown to become a giant like the tree behind it.
C. Küchli

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Three hundred years of sustainable forestry

Foresters tend to take a long-term view because trees take so long to grow. That may explain why foresters have led the way in developing the modern concept of sustainability.

There are debates on where, when and by whom this concept arose, but in this edition of *Unasylva*, Schmithüsen makes a case for Hans Carl von Carlowitz as the catalytic figure. Three hundred years ago this year, von Carlowitz, a German mining administrator, was vexed by the dwindling supply of wood for the silver mines he oversaw, and he was critical of the profit-driven thinking that was causing overharvesting of the forest. He published a book, *Sylvicultura oeconomica*, in which he coined the German term for sustainability, *Nachhaltigkeit*. Von Carlowitz said that the *Nachhaltigkeit* principle should be applied to the management of forests to ensure the perpetual supply of timber, and he urged the adoption of measures that would make forests a permanent economic resource. Over the next decades and centuries, the *Nachhaltigkeit* principle spread through Central Europe and to India, the United States of America and elsewhere. Arguably, it was the start of the modern approach to sustainable forest management (SFM).

According to an article by Küchli, forestry in Switzerland was influenced strongly by German approaches, but in the late 1800s it diverged towards what became known as close-to-nature forestry. This approach moved away from the earlier tendency to simplify forest stands towards the development of mixed, naturally regenerating stands composed mainly of local species. Küchli thinks that close-to-nature forest management could be the most effective strategy in the face of climate change.

Ball and Kollert report on the little-studied *Centre International de Sylviculture*, the first country-membership-based international forestry organization, which was established in Berlin, Germany, in 1938. The organization was short-lived, but it managed to accumulate a library of more than 15 000 books, some of them rare editions dating to the 1600s. Not all the books in the collection survived the Second World War, but those that did – more than 10 000 of them – were transferred in 1948 to the newly established Food and Agriculture Organization of the United Nations, where they remain today.

Changing tack, Sarre and Sabogal ask whether SFM is an impossible dream. Using certification as a proxy for SFM, they report that nearly 20 percent of forests designated for production or multiple uses were under management consistent with SFM in 2012, the majority in temperate forests. The authors describe some of the obstacles to SFM in the tropics, and they answer their own question by asserting that SFM is not a fantasy – it is an essential pursuit.

In his article, Appanah reviews silvicultural models applied in tropical rainforests in Southeast Asia and finds that none has fully demonstrated sustainability, at least partly because overharvesting has limited the extent to which they have been implemented. Technically, says Appanah, there is little reason why SFM cannot be achieved in tropical rainforests by improving silvicultural and harvesting practices, but the real struggle is to convince the holders of land and land-use rights that SFM is in their interests.

Tongkul and co-authors examine efforts to strengthen community involvement and the use of traditional knowledge in forest management in Sabah, a state of Malaysia. The Sabah Forestry Department has been willing to engage local communities in addressing long-standing problems in forest reserves, but the key issue of resource ownership is still to be tackled. The authors say this is critical to the survival of indigenous communities, who want formal ownership of the land to which they have customary rights.

Matta and co-authors develop this theme further. They acknowledge the long history of SFM in traditional communities in India, and report on social research that shows how traditional communities work cooperatively to conserve and sustainably manage their common resources. While there have been attempts in India to engage local communities in SFM, these have generally fallen short of the ideal. The restoration of traditional management systems in India, say the authors, requires the transfer of power, resources and responsibility from central authorities to lower levels of governance.

A short article by Aggarwal and co-authors looks at the makers of traditional wooden toys, which play an important cultural role in India. The resource on which this craft is based has dwindled due to overuse, and the authors suggest steps that can be taken to ensure the continuation of this artisanal pursuit.

This edition of *Unasylva* opened with an article looking back 300 years, and it finishes with one that looks forward an equal distance. Blaser and Gregersen speculate on the future role of forests, given climate change and expected increases in population and resource consumption. The fate of humanity, they say, rests in large measure on how we deal with forests. Optimistically, they believe that, 300 years from now, forests will be highly valued by the global community, as will their managers. There will be many challenges, and forest managers will need a wide range of skills. SFM has come a long way since von Carlowitz's day, but it is likely we will still be perfecting its art and science for some time to come.

Mit GOtt!
SYLVICVLTVRA OECONOMICA,
Oder
Haußwirthliche Nachricht und Naturmäßige
Anweisung
Zur
Wilden Baum-Zucht,
Nebst
Gründlicher Darstellung/
Wie zu förderst durch Göttliches Benedeyen dem allenthalben und insgemein einreissenden
Grossen Holtz-Mangel/
Vermittelst Säe- Pflantz- und Versetzung vielerhand Bäume zu prospiciren/
Alles zu nothdürfftiger Versorgung des Hauß- Bau- Brau- Berg- und Schmelz-Wesens/
Worbey zugleich eine gründliche Nachricht von den in Churfl. Sächß. Landen
Gefundenen Turff
Dessen Natürliche Beschaffenheit / grossen Nutzen / Gebrauch und nützlichen Verkohlung.
Von
Hannß Carl von Carlowitz/
Königl. Pohl. und Churfl. Sächß. Cammer-Rath/und Ober-Berg-Hauptmann.
Mit Königl. Pohl. und Churfürstl. Sächß. allergnädigsten PRIVILEGIO.
LEIPZIG/
verlegts Johann Friedrich Braun 1713.

***A facsimile of the front cover of the first edition of von Carlowitz's seminal work,* Silvicultura oeconomica**

Three hundred years of applied sustainability in forestry

F. Schmithüsen

The scientific approach to forestry has evolved from sustainable wood production to multifunctional forest management.

Franz Schmithüsen is Emeritus Professor, Forest Policy and Economics, Swiss Federal Institute of Technology, Zurich, Switzerland.

Today's guiding principle of sustainability has its origins in forestry. In 1713 – 300 years ago this year – Hans Carl von Carlowitz, a German, published his book *Silvicultura oeconomica*, which advocated the conservation, growing and use of wood in a continuing, stable and *sustained* manner. This was the first documented use of the German term for sustainability, *Nachhaltigkeit*. Arguably, it was also the start of a scientific approach to forestry, which ultimately expanded from Central Europe to the rest of the world. This article uses historical and contemporary sources to show how the principle of sustainability has permeated approaches to forestry beyond Europe and remains the guiding light of forestry today.

THE BEGINNING

Early reactions to forest overuse and degradation

Many early measures were taken to help conserve forests in Europe. In Germany, for example, common law as early as 1330 mentioned that woodcutting should be moderate and carried out without causing devastation (Mantel, 1990). Specific rules were adopted by villages, communal land associations, monasteries and towns. Measures included a ban on felling trees that yielded foods (e.g. fruits) and non-wood forest products. Forests near settlements were reserved for the use of local people and divided into coupes (rotation areas) to be harvested annually, after which such areas were to be protected from grazing until tree regeneration was assured.

In medieval France, the concept of sustainability appeared in the use of the Old French word *soustenir*, "to sustain", a technical term used in the *Ordonnance de Brunoy*, which is the first known French law dealing with the management of waterways and forests. Enacted in 1346 by King Philippe VI, the law stipulated that: "The owners of waterways and forests will make enquiries about and visit all forests and woods and will conduct sales that will allow the aforementioned forests to perpetually sustain themselves in good condition".

In Britain, John Evelyn's *Sylva: a discourse of forest-trees and the propagation of timber in His Majesty's dominions*, was presented to the King, the Royal Society and the public in 1664 (Grober, 2007). The book was reprinted several times during the seventeenth century and encouraged the planting of millions of trees, albeit in the parklands surrounding the country estates of landed gentry and the aristocracy.

Growing demand

Ultimately, though, such early efforts to ensure the conservation and management of forest resources were insufficient. The growing demand for wood in Europe in the seventeenth century for early industrial processing led to increasingly intensive prospecting for usable forests and the systematic exploitation of newly opened forest stands for wood (Mantel, 1990). In Germany, Austria and Switzerland, the need to supply the mining and salt production industries was urgent. In coastal countries such as Britain, France, Portugal, Spain and Sweden, maintaining a wood supply for shipbuilding was one

***An etching of woodcutters that appeared in von Carlowitz's* Silvicultura oeconomica**

of the main concerns. The push for wood and agricultural land led to large-scale tree-felling, complete forest clearance and inadequate regeneration. This had serious negative effects on forest condition, as evidenced by the contemporary reactions of independent observers and campaigns by local inhabitants, and by desperate descriptions of cleared areas and overused forests. Deciduous and mixed forests declined, and there were changes in the distribution of tree species such as beech, oak, pine and fir. By the beginning of the eighteenth century, the demand for wood could no longer be met by expansion into previously unused forests.

VON CARLOWITZ AND THE MOVE TO *NACHHALTIGKEIT*

In 1713, as head of the Saxon mining administration, Hans Carl von Carlowitz (1645–1714) published *Sylvicultura oeconomica, oder haußwirthliche Nachricht und Naturgemäße Anweisung zur Wilden Baum-Zucht* (in brief, *Economics of silviculture: instruction for cultivating wild trees*). In this 300-page treatise, von Carlowitz drew on his experiences, the written materials of others, international contacts and visits, and his own conviction that a new approach to using forests in a sustainable manner was required (see box). A second, augmented edition of the book, with a new section by the editor Julius Bernhard von Rohr, appeared in 1732, 18 years after von Carlowitz's death. The text became a must-read, not only for generations of foresters but also for state administrators and managers in the mining industry. *Sylvicultura oeconomica* can still be read without difficulty, and in many respects its content is as fresh and relevant today as it was when it was written.

In *Sylvicultura oeconomica*, von Carlowitz wrote about the lack of wood and its causes and noted "that, over time, many provinces of Europe will have great forests logged over and made thin". He not only set out a framework for a modern forest and wood-processing sector, he also created the term *Nachhaltigkeit* ("sustainability")

Hans Carl von Carlowitz

Hans Carl von Carlowitz, 1645–1714

The son of a forester, Hans Carl von Carlowitz was born in the Saxony town of Chemnitz, Germany, towards the end of the Thirty Years War. He studied law and public administration in Jena, learned foreign languages, and as a young man spent five years on a tour of Europe that spanned from Sweden to Malta and included lengthy study stays in Leyden, London and Paris (Grober, 2010, 2012). On his return to Germany, von Carlowitz entered the state service. In 1677, at the age of 32, he became the administrator of mining, and in 1711 he was put in charge of the mining industry at the court of the Electorate of Saxony. He lived in Freiberg, in the foothills of the Iron Mountains (*Erzgebirge*), known for their silver mines.

The Saxony mines were flourishing, employing about 10 000 miners. Their smelting furnaces devoured enormous quantities of charcoal, firewood and construction timber, and von Carlowitz was responsible for ensuring the wood supply. Thus, he was confronted with the industry's greatest problem at the time – a lack of wood. Large areas of forests had been exploited, and the devastated areas were unlikely to be productive again for many years. Trees had been cut-over for generations, old-growth forest had disappeared, and no effort was being made to regenerate the forests. The extensive grazing of cattle, pigs and goats, as well as subsistence agriculture, impeded forest recovery. In many cases these agricultural practices had long-lasting consequences for forest soil fertility, exacerbated by practices like litter-gathering.

DETLEV MÜLLER

Modern-day Freiberg, Germany

Von Carlowitz was strongly critical of the short-term thinking, driven by quick profits, that led to the ruthless exploitation of forests for their wood and then to their conversion to agriculture. He developed ideas intended to ensure a lasting supply of wood and to create a permanent economic resource. He suggested other measures that are still central to sustainability today, such as improving the insulation of houses, using energy-efficient smelting furnaces, and improving agricultural land management practices.

Most important was his forcefully argued and simple message that there would be no future wood supplies if the cut-over areas were not replanted systematically. This implied not just comprehensive legal and economic measures undertaken by the state, but a complete rethinking of the forestry problem and a major effort to persuade people

box continues

continued from previous page

to plant trees and maintain forest regrowth. It also required establishing a competent forest service with specialists who understood both the biological basis of tree-planting and the managerial tasks of developing a permanent wood production regime.

***Sylvicultura oeconomica* was written in the tradition of mercantilism, which was the prevailing economic theory of his times. It brought a new, rational approach to society and change as well as to humanity's understanding of nature and its relationship to it. It was conceived in the spirit of the Enlightenment and the Age of Reason, and marked the beginning of forest science and teaching.**

By no means does the work of von Carlowitz stand alone. He learnt from others and others came to learn from him. With his wide knowledge of the literature, he had the ability to compare the forest situation in Saxony with that in other European countries. He was well aware of innovative efforts undertaken elsewhere to develop new approaches and a more productive use of land in both agriculture and forestry. During his stay in France he became familiar with Colbert's legal reforms, which led to the Forestry Code of 1669. He quoted the new code extensively in his book, saying that it already contained most of his own work. He visited the forest of Montello in the Alto Adige, which was managed by the city of Venice for the supply of hardwoods for the Venetian fleet. And he likely knew John Evelyn's *Sylva* (see main text).

by referring to the concept of *nachhaltige Nutzung* ("sustained use"). He provided a definition for what became, in following decades, the basic concept of forest management:

> *The greatest art, science, diligence and institution of these countries will rely on the manner in which such conservation and growing of wood is to be undertaken in order to have a continuing, stable and sustained use, as this is an indispensable cause, without which the country in its essence cannot remain.*[*]

Von Carlowitz's concept of sustainability was further developed by others. In his book *Grundsätze der Forst-Ökonomie* (*principles of forest economics*), Wilhelm Gottfried Moser (1757), an administrator and forester, referred to the intragenerational and intergenerational elements of *Nachhaltigkeit*: "A sustainable economy is as reasonable, just and wise as it is certain that man must not live only for himself, but also for others and for posterity". Georg-Ludwig Hartig (1795) formulated the principle of sustainability from an intergenerational perspective, remarking in his textbook *Anweisung zur Taxation der Forste oder zur Bestimmung des Holzertrags der Wälder* (*Taxation of forests*) that:

> *It is not possible to think about and expect sustained forestry if the wood allocation from the forests is not calculated according to sustainability … Any wise forest direction consequently needs to tax (assess) the woods as high as possible, but aiming at using them in a way that the descendants can draw at least as many advantages as the now-living generation appropriates.*

In this last phrase it is possible to see the seeds of the modern concept of sustainable development, which the World Commission on Environment and Development (1987) defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs".

In 1841, Carl Heyer referred to the sustainability of wood production when he remarked that a forest could be considered to be "managed in a sustainable manner if one takes care of the regeneration of all logged stands in order to maintain the soil that is destined for forest production". The Swiss forester Karl Albrecht Kasthofer, who had studied in Heidelberg and Göttingen, translated the meaning of *Nachhaltigkeit* as the "sustained and equal product of a forest".

THE PRINCIPLE OF *NACHHALTIGKEIT* SPREADS

Europe

Nachhaltigkeit started to become a reality in science-based forest research and education in the early 1800s (Grober, 2007). The first privately run schools to teach practical forestry were founded in the Harz Mountains and Thuringia (Germany). Heinrich von Cotta established a school in Tharandt (in Saxony, Germany) in 1811. There were strong professional relations between Germany and France: Bernhard Lorentz, a native of Alsace in France and a life-long friend of Georg Ludwig Hartig, became the founder and first director of the French National Forestry School in Nancy. This school was established in 1824, followed quickly by the enactment of the French Forestry Code in 1827.

Step by step in Europe, policies and laws introduced and normalized principles of renewable natural resource use. Silvicultural models of wood production were developed, adapting wood harvesting to the long-term productive capacity of forest stands. European forestry professionals and scientists became well known, and technical schools and academies gained reputations and attracted foreign students. Graduates from these schools travelled to other countries and spread the idea of sustainable wood production. Johann Georg von Langen, an influential German forester, for example, worked for many years as an adviser to the Danish court, helping to build principles for forest resource management in Denmark and Norway.

Tsar Peter the First ("Peter the Great") and Tsarina Katharina ("Catherine the Great") used German experts when establishing

[*] Translations are by the author.

a forestry profession in Russia. Peter the Great visited Saxony in 1698 and returned to see von Carlowitz in 1711 and to visit one of the salt mines. Later, he recruited miners from Saxony to build up the mining industry in Russia (Grober 2010, 2012). The oldest forest education institution still in operation today is the St Petersburg Forest Academy, which was established in 1803. In the mid-nineteenth century, Spanish and Portuguese students received grants to study forestry in Germany and were critical in the establishment of the first forest schools and modern forest administrations and forest codes in their native countries (Rojas-Briales, 1992).

Below, the examples of India and the United States of America illustrate the spread of the principle of *Nachhaltigkeit* beyond Europe.

India and Burma

In British-ruled India, the felling of trees was unregulated in the first half of the nineteenth century. In 1850, at the initiative of Hugh Cleghorn, the British Association in Edinburgh formed a committee to study forest destruction. In 1855, Lord Dalhousie, governor-general of India, issued a memorandum calling for forest management.

Dietrich Brandis was born in Bonn, Germany, and studied at the universities of Copenhagen, Göttingen, Nancy and Bonn; he became a lecturer in botany in the latter. He joined the British Imperial Forest Service in 1856 as superintendent of the teak forests in eastern Burma. After seven years in Burma, he was appointed inspector-general of forests in India and held that position for 20 years. He promoted the "taungya system", an early form of agrosilviculture: villagers provided labour for clearing, planting and weeding teak plantations and in return were allowed to plant food crops between the teak saplings in the early years of the cycle before the tree canopy closed. As the distance between the village and each newly established forest area grew, however, the plantations became increasingly difficult to maintain and later there was local resistance to them (Gadgil and Guha, 2006).

Brandis developed teak growth-and-yield tables as a reliable basis for determining allowable annual cutting volumes under a sustainable management regime. Forest protection plans against tree disease and fire were drawn up, timber purchasing rules were formulated, and extensive teak plantation schemes were planned and implemented. The Indian Forest Service, with administrative and operational districts under the responsibility of forest conservators, was established, with Brandis at its head. Brandis also prepared new forest legislation and helped establish forest research and training institutions – in particular, the Imperial Forest Research Institute at Dehra Dun in 1906. Many of the accomplishments of Brandis were of interest in other countries in Asia and Africa and contributed to the spread of sustainable forestry practices.

TONYNIRAPPATHU

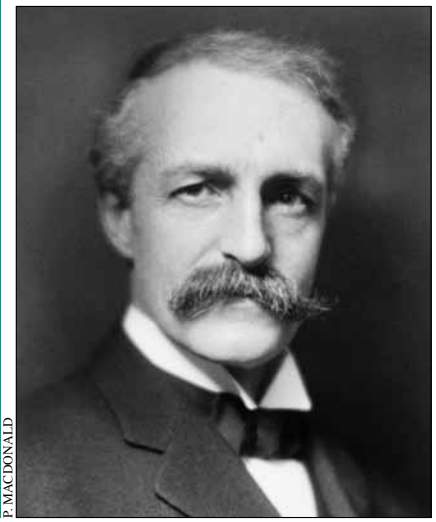
The world's largest teak tree, Parambikulam forest, Kerala, India

The United States of America

The concept of *Nachhaltigkeit* reached the United States of America through several channels. One was Bernhard Fernow (1851–1923), who studied forestry at the University of Königsberg and the Forest Academy in Münden before marrying an American woman and settling in the United States. As chief of the Division of Forestry in the United States Department of Agriculture from 1886 to 1898, Fernow's focus was on establishing a national forest system, introducing science-based forest management, and protecting forested watersheds. From 1898 to 1903 Fernow was the first dean of the New York State College of Forestry at Cornell, and in 1907 he became the founding dean of the University of Toronto's Faculty of Forestry in Canada. He established the *Forest Quarterly* (which later became the *Journal of Forestry*) at Cornell in 1902 and was that publication's editor-in-chief until his death.

Scientific and professional ties between the United States and Europe strengthened during the career of Gifford Pinchot (1865–1946). After graduating from Yale University in 1889, Pinchot followed the advice of Dietrich Brandis, at the time a professor in Bonn, and enrolled in a one-year forestry course for senior officials specializing in forest management at the French National Forestry School in Nancy. During his time in Europe, Pinchot became familiar with the work of high-level scientists and researchers, both through personal contact and from reading the literature, and he also learned from experienced forest practitioners and from forest excursions he made in France and Germany. In his later career in the United States, Pinchot returned several times to Europe to visit scientists and colleagues he had met during his stay in Nancy. In 1898 he succeeded Fernow as head of the Division of Forestry. In 1905 Pinchot was appointed chief of the newly established United States Forest Service, of which he was in charge until 1910.

Gifford Pinchot in 1909. At the time of this photo he was the first Chief of the United States Forest Service



P. MACDONALD

Pinchot understood that if they were to engage in tree-planting as an economic venture, Americans needed clear and convincing evidence that sustainable forestry by private landowners would repay the funds invested by generating income – in the short term as well as the distant future. Pinchot also believed that the system on which European *Nachhaltigkeit* was based was not the way to proceed in the United States. In much of Europe at the time, the general citizenry was little involved in the use and management of state and communal forests, and decision-making was left to an admittedly competent and dedicated state forest administration. During his stay abroad, however, Pinchot had noticed that the Sihlwald of Zurich was an exception – an example of *Nachhaltigkeit* in which local people had a direct say. Pinchot believed that the United States, with its democratic political system, would not achieve a shift to sustainable forestry without the consent and active participation of its citizens. A comprehensive policy of natural resource conservation and preservation required the understanding and support of the American public, private landowners and policy-makers.

Pinchot's book, *Breaking new ground*, published posthumously in 1947 (Pinchot, 1947), provides a breathtaking insight into the origins of sustainable forestry in the United States. Pinchot was able to combine his knowledge of forestry with a profound understanding of the political, economic and social circumstances determining the development of sustainability in his country. The book remains relevant today because it addresses many issues that are fundamental to forest development in modern societies.

BUILDING A MULTIFUNCTIONAL FOREST SECTOR IN EUROPE

The process of building a productive forest sector in Europe during the nineteenth and twentieth centuries is a model for promoting the sustainable management of renewable resources in other sectors. The decisive aspect during the transition from local forest management regulations to the implementation of the *Nachhaltigkeit* principle was the recognition that forests could be used permanently as renewable resources for profitable and efficient commercial and industrial activities while maintaining and even increasing their productive capacity. In Europe, growing stock and annual increment have both increased since the beginning of the nineteenth century, thanks to highly developed silvicultural practices that conform to the *Nachhaltigkeit* principle. Considerably larger volumes of roundwood can be harvested sustainably today than were available two hundred years ago.

During the nineteenth century there was a separation of the agricultural and forestry production systems as efforts were made to intensify the production of arable land and pasture on the one hand and to limit damage to forest stands and establish the conditions for increased wood production on the other. This led to important landscape changes: for example, many biodiversity-rich biotopes that had developed under less intensive land management systems disappeared or were reduced in size.

By the mid-nineteeth century, the sustainability of wood production had become a major consideration for foresters,

FAO/FO-7430/RAJENDRA K.C

Natural beech forest, Germany

both public and private, who calculated allowable annual wood harvest quantities in relation to the growth and yield of the available forest stands. One of the methods for regulating the rate of wood-harvesting was an area allotment system (*Flächenfachwerk*) that divided forest into annual harvest sections. The volume allotment method (*Massenfachwerk*) was later introduced to account for differing wood-supply capacities, by area. In this latter method, the usable total growing stock was divided according to the planned rotation period. More recent methods include management regulations based on the annual increment of forest stands, and the control method, in which the sustainability adjustment is based on a periodic assessment of the development of the growing stock.

The widespread use of coal and oil, improvements in infrastructure and the intensification of agricultural production based on mechanization and fertilizers reduced pressure on forests to produce wood as an energy source and created conditions under which forests could be used as a lasting supply base for industrial wood-processing. Putting the *Nachhaltigkeit* principle into practice meant adjusting the intensity of felling to the long-term production potential of forest stands and sites. Silvicultural techniques were developed for regeneration, the tending and thinning of young stands, and matching species to site conditions and end uses. Forest ecology became an important discipline in forestry research and development (Dupuy, 2005).

The importance of tenure

Ensuring the continuity of and increasing the wood supply required considerable private and public investment, but this could not be obtained without secure forest tenure. The current property rights structure in European forests was established largely in the nineteenth century. Forest lands were surveyed, mapped and entered into land registries. Defining, clarifying and formalizing forest ownership rights, and physically marking ownership boundaries on the ground, were among the most significant contributions made by forest laws during the nineteenth and twentieth centuries.

The first generation of forest laws in Europe tended to restrict or abolish usufruct rights and transform collective tenure into clearly defined private, communal and state landownership. Customary private and collective use rights were legally registered, or forests still under collective tenure were divided among users and became private forests. In other cases, communal and state forests were confirmed or created. Quite often, a combination of private and public forest tenure developed. More recently, the distribution of property and use rights has changed as a result of the sale of forest land, the afforestation of former agricultural areas, and political and constitutional changes.

Legal requirements usually focus on protecting forest cover, setting minimum standards for sustainable management, and ensuring increased productivity. New forest laws generally aim to protect

landowners' wood production and their right to use their forestland as a productive asset for generating income and profit. The laws also determine landowners' responsibilities for serving certain purposes in the public interest, such as watershed protection, by stipulating the maintenance of permanent forest cover.

In Spain, two main historical events were of particular importance for the distribution of land use and tenure. The first was the *Reconquista* (the reconquest of Moorish Spain in the Middle Ages), which had significant consequences for land development in the pre-industrialization period of the late eighteenth century. The second was the forced sale of church, municipal and crown forests in the nineteenth century, known as *desamortización*. This process, affecting at least 4.5 million hectares of forest (18 percent of the total forest area), was in line with liberal post-French Revolution thinking but was applied in Spain in an exceptionally unstable political environment. The expected advantages were very limited, and many authors identify it as a cause of the country's last deforestation wave (Rojas-Briales, 1996).

FOREST MANAGEMENT IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

Today, silviculturists in Europe use a range of harvesting techniques and regeneration methods to achieve stable and sustainable forest production. Efforts to promote natural regeneration and a proportion of deciduous trees in planted coniferous stands have intensified, especially in Central Europe. The conservation of genetic resources and landscape features while maintaining the capacity of forests to adapt to changing environmental conditions is now a major silvicultural goal in most European countries. Close-to-nature forest practices (Küchli, 2013) help maintain the diversity of forest stands while providing flexibility in production and creating attractive, varied landscapes.

What forests mean today to people living in largely urbanized European societies is an interesting subject of debate and social research. The findings of such research confirm, first of all, that forests continue to be seen as a usable and productive part of the human environment, and that their management is conditioned by economic and social preferences and competition with other materials. Because wood is a renewable resource that can be managed sustainably, and because forests have a largely carbon-neutral life cycle, the production and use of wood is an essential political option in efforts to protect the environment and mitigate climate change.

At the same time, empirical studies show that forests have acquired new meaning and significance in society. The aesthetic values of trees and forests were already acknowledged at the turn of the twentieth century (von Salisch, 1902). For a growing part of the population today, the forest represents a space for recreation that is different from more intensively used areas. Increasingly, Europe's forests are seen as natural; people perceive them as representing the free interplay of natural forces, in contrast with inhabited areas and land exploited intensively for agriculture. This perception reflects the needs and preferences of a growing part of contemporary society and the desire of urban populations for relaxation in natural surroundings. Forests address a need brought on by growing threats to the

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Mixed broadleaf forest, Germany

global environment, including the loss of biodiversity. For a large number of people, forests are places for meditation, reflection and personal freedom.

Under *Nachhaltigkeit* today, forest practices address a range of forest uses, societal values and management systems. The concept of priority functions allows approaches that determine which management priorities are assigned in a given forest stand. Accordingly, managers prioritize their objectives and the measures that must be taken to achieve them, and they limit or avoid uses and interventions that are incompatible with priority forest functions. Such a process-steered approach provides, for example, transparent evidence of performance in preserving the stability and productivity of protected forests. Distinguishing priority functions in given forest areas is useful whenever divergent interests lead to conflicting goals in natural resource management. Priority functions may relate to entire geographically delimited landscapes and watersheds or to units such as forest stands and biotopes.

Balancing private and public interests in management planning, seeking agreement among stakeholders with divergent interests in preparing national forest programmes, and creating workable arrangements for landowners facing public demands for the services provided by their forests have all become important forest-policy objectives. Such requirements are the result of a major shift from governmental and hierarchical regulatory systems to formalized negotiation procedures, public process steering, and joint management responsibilities. Close-to-nature forest management systems allow managers to adapt their strategies to meet changing societal values, leaving options open for alternative uses and new developments.

CONCLUSION

In the face of pressing demands for environmental protection and the conservation of biodiversity on a large scale, it is not the principle of *Nachhaltigkeit* that is in question today, but certain forest practices that are deemed incompatible with sustainable development. The legacy of von Carlowitz and his approach to forest management is capable of taking into account profound currents of opinion in society. Multifunctional forest management can react flexibly to diverse social interests and adapt forest management to local social and environmental conditions. It provides multiple options for responding to market trends and the changing needs and values of society, while not precluding options for future generations.

Sustainable forest practices have developed steadily since von Carlowitz's day. His central idea formed the basis of the long subsequent history of forestry development. But the goals of sustainable forestry – nowadays called sustainable forest management – and the strategies to achieve them have been adapted over time as environmental and socio-economic conditions have changed. The secret for achieving sustainable forest management is to maintain the principle of sustainability while adapting forest management strategies to changing circumstances. In this, forestry has shown the way for other natural resource management sectors. ◆

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The Swiss experience in forest sustainability and adaptation

C. Küchli

C. KÜCHLI

Natural regeneration in this close-to-nature Swiss lowland forest will ensure that, when mature trees are felled, younger trees are ready to take their place

Close-to-nature forest management has been practised in Switzerland for more than 100 years and could be crucial for minimizing risk in the face of climate change.

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Forests in Switzerland have been managed for thousands of years; for example, there is evidence of well-ordered oak forest management 5 000 years ago in the early Bronze Age (Gassmann, 2007). Since the fourteenth century, documents written by local communities provide evidence of their efforts to secure the protective functions of forests, wood supply and other forest services. Forests have long provided villagers with energy for cooking and heating, construction wood, fodder, autumn leaves and moss for fertilizing fields, food such as mushrooms and berries, medicines, and much more. Thus, the forests of Switzerland, even in the most remote valleys, have been used – more or less intensively – for centuries.

For centuries, too, the cities of the lowlands relied heavily on wood. Around 1800, the forests near urban centres began to show signs of resource exhaustion and conflicts arose over their use. Clearfelling in the mountains for wood-hungry cities or for export contributed significantly to the catastrophic floods of the 1860s, which had widespread effects on the lowlands and cities.

A serious endeavour in forestry was required. This article describes the

development of forestry in Switzerland, which at the beginning followed methods developed in Germany and then branched off to a close-to-nature approach to forestry, which today is employed throughout Switzerland.

THE MODERN BEGINNING OF SUSTAINABLE FORESTRY

Many of today's forests were established in the context of the devastation arising from the quest for energy and raw materials; in that sense, wood scarcity and catastrophe are the parents of the mature forests in Switzerland today. The classical German forestry model that was developed in Prussia and Saxony in the middle of the eighteenth century initially had a strong influence on the development of Swiss forestry. In the mid-1800s forest use was oriented toward a constant wood harvest – in other words, a sustainable harvest – as advocated by Hans Carl von Carlowitz in 1713 (Schmithüsen, 2013). If the forest was "capital", only the growth – "interest" – was to be harvested. To regulate the harvest, tree populations were organized like a chessboard. Each year a square would be clearfelled and afterwards reforested, often with a single tree species. The goal of German forestry and thus Swiss forestry in that period was to produce as much wood as possible in the short term. Spruce (*Picea abies*) and pine (*Pinus silvestris*) were the chosen species in this model.

Prior to enactment of the first national Swiss forest law, significant areas of broadleaved species near cities were clearfelled and the roots dug up for firewood. Such clearing was often followed by several years of agriculture, mostly potato production, after which spruce or other conifers were planted, often in monocultures, following the German model. Exotic species from North America such as Douglas fir (*Pseudotsuga menziesii*) and Weymouth pine (*Pinus strobus*) were also used. Even today, there are stands that bear the mark of this history.

THE NATIONAL FOREST LAW

Diverse developments in the economic context of forests played an important role in the realization of the sustainability concept in Swiss forests. The construction of railways in the 1850s was decisive because it allowed the importation of coal, fertilizers and food. The age of coal enabled industrialization. The first train entered Bern in 1858, and within two years coal had become cheaper than firewood in the city.

These developments in the energy and economic sectors reduced pressure on forests and their many products and made possible the introduction and implementation of the first national Swiss forest law in 1876. It is a myth, therefore, that this law alone saved Swiss forests, as argued by some (Küchli, 1997), although it has been hugely influential. It was conceived as a

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Foresters discuss the use of a soil penetrometer. Soil fertility has improved tremendously under close-to-nature forest management

framework law, and with several revisions it is still in force today. The law maintained the existing forest ownership structure but in the interest of the whole – including future generations – it introduced strict controls on management by public and private owners. From the beginning, the federal government provided the cantons (analogous to provinces or states in other federal systems) with financial support to enable them to employ forest officials. The most important article of the national forest law pertains to forest area, which may not decrease in size unless it is in the overarching public interest, for example the construction of a railway line. If an area of forest is cleared, an equivalent area elsewhere must be afforested. This rule, which still applies today, is the reason that the cultivated landscape of Switzerland, with its typical pattern of forested and open land, has remained practically unchanged for a century and a half (Küchli, 1997).

By the 1880s, nature had begun to work its wonders: bit by bit, the trees and forests made their way back on degraded land. In remote areas, trees naturally repopulated landscapes, while, in the lowlands, trees were often planted. Even in those times, the pros and cons of planted versus naturally regenerated trees were the subjects of difficult discussions among foresters. In 1868, for example, one forester expressed the fear that if foresters did not plant, they would be laughed at, and people would say, "if nature can do everything by itself in the forest, we don't need any foresters" (Küchli, 1994). For the early Swiss foresters it was important to produce quick results, just as it is today in many forestry projects, especially in developing countries.

But nature was not always benevolent. The mistakes of the young forestry profession, such as inappropriately planted exotic species or spruce monocultures, were exposed pitilessly by infestations of insects and disease. Swiss foresters began to understand that the closer to nature were their forests, for example in their structure and species composition, the better the trees would withstand storms and disease in the course of their long lives.

HENRY BIOLLEY AND THE BEGINNINGS OF CLOSE-TO-NATURE FORESTRY

At the end of the nineteenth century, in the forests of Couvet near Neuchâtel, the Swiss forester Henry Biolley refined the single tree selection method. For many centuries in those forests, a limited number of trees in a given area were harvested according to the specific use to which they were put – for example, strong trunks for construction and young firs for beanpoles. Over time, this felling of single trees or small groups of trees had a marked impact on the structure of the forest: large firs grew next to small spruces, and vice versa. Using this traditional forest-related knowledge, Biolley developed a vision of a "family forest" in which fir, beech and maple would cohabit in a multistoried mixture, from saplings to large trees.

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In Switzerland, if a forest is cleared to make way for a new development in the overarching public interest, an equivalent area must be afforested

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Spruce logs lie stacked in a Swiss alpine forest, ready for transport to the mill for the production of high-value products

Biolley described this form of forest management, which today we call close-to-nature forestry, as experimental because it was flexible and oriented to the situation rather than following a fixed plan. Of course, an experiment without oversight can fail. To record the effects of his approach, Biolley set in place a tree measurement procedure that had been invented by the Frenchman Adolphe Gurnaud and presented at the World Expo in Paris in 1879. In refining Gurnaud's method, which enabled the measurement of tree growth in stands of trees with differing diameters, Biolley laid an important foundation for the liberation of foresters away from the chessboard approach towards a more subtle approach that allowed uneven-aged stands.

For Biolley, irregularity was a characteristic of nature, whose laws should be followed as closely as possible. He was one of the first of his profession to consider the forest as an organism. He recognized the potential of natural regeneration, and in this he made his mark on Swiss forestry. Similar developments were also occurring in German forestry: in 1922, Alfred Möller presented his treatise called *The permanent forest* in which he described a forest featuring trees of differing ages and species and in which the self-regulation mechanisms of nature were applied in order to achieve silvicultural goals. His approach greatly stimulated discussion on close-to-nature approaches.

Minimizing risk

By about 1900, therefore, Swiss foresters had learned to appreciate the natural regeneration potential of trees, and the short historical phase of plantation forestry with clearfelling was abandoned in most places. Trees were harvested in small groups or as single stems, and natural regeneration became predominant. This did not, however, preclude enrichment planting with favoured tree species, such as spruce or beech (for centuries, beech had been cut for firewood and therefore was no longer or was only sparsely present in many areas). All these developments can best be understood under the overarching goal of minimizing risks through an adaptive silviculture. The chessboard approach involved considerable economic and environmental risk: single species – sometimes of unknown provenance – planted over large areas were prone to storm damage, pest outbreaks (such as bark beetles) and other risks. Close-to-nature forestry was increasingly seen as a way of controlling and gradually diminishing such risks with simple silvicultural measures.

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The timber cut in this alpine forest is extracted using cables to minimize soil disturbance and the risk of avalanche

FROM QUANTITATIVE TO QUALITATIVE SUSTAINABILITY

Biological and ecological knowledge in European forests increased considerably in the first half of the twentieth century. The soil was no longer thought of as a dead substrate but as a richly populated root space. Insights into the nature of tree diseases showed that pathogens multiplied particularly in weakened host plants, and chemical treatments were not the answer.

Under the coordinated leadership of Hans Leibundgut, professor of silviculture from 1940 to 1979 at the Swiss Federal Polytechnical School in Zurich, these and many other findings from close-to-nature forestry were consolidated and adapted to the peculiarities of Swiss forests. The overall objective of the approach is a forest ecosystem that is stable in the face of external disturbances such as storms, or which recovers quickly after such events. The influence of those who use the forest should be as low as possible and should be aligned with natural processes. In Leibundgut's time, forest management ceased to be geared towards producing as much wood as possible; the emphasis shifted instead toward the management of ecosystems to provide a wide range of products – such as high-value timber – and services such as catchment protection, biodiversity conservation, clean air and recreation (Leibundgut, 1975).

The results of the concepts and methods that were initiated by Henry Biolley and further developed and consolidated in Leibundgut's time are best explained by an examination of the forests where the process began. In 1890, Biolley measured all trees in the forests of Couvet greater than 17.5 cm in diameter, and his seven successors continued that practice, which has been maintained up to today. There may be no other forest in the world that has been measured so consistently and managed according to the same principles for so long. The collected data contain a wealth of unique information. Well over 1 000 m^3 of wood per hectare have been harvested on the exposed northern flank of the forest since 1890 – an average of about 10 m^3 per hectare per year. Compared with the state of the forest in 1890, the structure and composition are now greatly improved – there is more standing volume and many more high-value stems. Today,

one-fifth of the trees are broadleaved; in Biolley's time, those species had practically disappeared.

For these changes to have taken place, several framework conditions were necessary. Biolley found a forest area with secure tenure and a forest structure with good preconditions for the application of his tenets. His successors worked strictly in the same direction. Fellings were carried out by well-trained forest workers, and over time a relatively dense network of forest roads developed to allow access to the dispersed felled trees. It has always been possible to sell these trees at a healthy profit, or, in times of low prices, to at least cover costs. Finally, the community of Couvet – the forest owners – have always stood by their forests and supported the efforts of the forest stewards.

The fundamental principles of close-to-nature forest management such as that implemented in Couvet could be applied in many other European forests as well as elsewhere, including the tropics (see box). Organizations such as Pro Silva Europe[1] are continuing to develop close-to-nature principles, including through a broad, country-spanning exchange of information. There is continuous development towards attaining mixed stands composed mainly of tree species that would grow naturally at a given location. In Switzerland, regeneration today is left mainly to nature (and therefore costs very little). This is shown in Swiss planting statistics: between 1980 and 2011, the annual quantity of planted trees declined from 7.5 million to 1 million seedlings. As long as a stand develops naturally in the direction of the management goal, no interventions are made. A similar approach is used as stands grow: natural and no-cost processes are taken advantage of, and minimal, directed, cost-effective interventions are carried out only when necessary.

[1] www.prosilvaeurope.org.

A KEY TO COMBATING CLIMATE CHANGE

The median air temperature of Switzerland has increased by 1.5 °C since 1970. This means that even if the international community can agree on measures to limit the global temperature rise to no more than 2 °C (a target agreed at the Conference of the Parties to the United Nations Framework Convention on Climate Change in Copenhagen in 2009), climate change in Switzerland will still be significant. If international negotiations fail and we have business as usual, an increase in the summer temperature of up to 4.8 °C is expected in the Swiss Alps by 2100 (The CH2011 Initiative, 2011). Significantly less rainfall is also projected.

Extreme events such as storms, heat waves, droughts and disturbances from pests could have major impacts on forests. Two events in the last decade provide a taste of things to come: a storm (called "Lothar") in 1999, and the 2003 summer heat wave. These two extreme events, and the resultant bark beetle infestations, were responsible for the loss of more than 8 million m^3 of spruce in Switzerland; many of the killed trees were remnants of the plantation period of a century ago. A changed climate directly affects tree growth, mortality and regeneration and in the long term would fundamentally alter many forests. Climate change will negatively affect many forest functions and services that are taken for granted today.

Close-to-nature approaches in the tropics

Close-to-nature forest management is a promising concept for tropical forests, and a variety of interesting parallels and connections exist between Europe and the tropics. At the end of the nineteenth century, Alfred Möller worked in the Brazilian rainforest, and his ecological research there was one of the key experiences that eventually led to his close-to-nature forest management concept (Bruenig, 2009). Forests can be managed according to the same fundamental principles applied in Europe and elsewhere.

Evidence of close-to-nature principles being applied in tropical forests can be found in many parts of the Amazon. Only recently has science begun to decipher traces that indigenous populations have left of their strong impact on forest landscapes. The distribution of Brazil nut trees (*Bertholletia excelsa*) is closely linked to the traditional forest-related knowledge of local peoples (Brazil nuts, also known as Para nuts, are long, oily nuts that these days can be found in almost any nut snack mix). Brazil nut trees are found in Amazonian forests individually and also in groups of dozens of individuals per hectare. Such large stands can only develop in clearings because *Bertholletia excelsa* is a light-demanding species in its early years. It is probable that, today, the larger groups of these trees are growing in what were once areas cultivated by indigenous people for cassava. Presumably the farmers planted the trees before they let natural tree succession take over again.

Very similar management practices can be observed in peoples such as the Dayak on the island of Borneo. The Dayak enrich small areas of cleared forest after dry rice cultivation with fruit trees or trees that produce resin or other tradable products. The area is then taken over by natural forest. The cycle repeats itself after decades or centuries. Huge tracts of rainforest that are considered to be untouched – that is, primary forest – are, in fact, traditional cultural landscapes. Since time immemorial, such landscapes have been managed according to what we could call close-to-nature principles.

The feasibility of close-to-nature forest management in tropical rainforests has been demonstrated by extensive scientific research (Bruenig, 2009). Clear tenure and use rights are a crucial precondition for the local populations to apply their rich forest-related knowledge and management experience.

It is not yet possible to determine the best forest management strategies in the face of climate change. Close-to-nature managed forests, however, offer *a priori* a good basis on which to start because they are resilient and have high adaptive capacity. Their resilience is based on their diversified structure and stability, and their adaptive capacity stems from their broad genetic diversity, which is a precondition for species to adapt to changing climatic conditions. The large number of trees that establish through natural regeneration means that there is an ongoing process of genetic recombination and consequently high genetic diversity in close-to-nature forests. This effect is even more pronounced in forests in which many old trees stand together in mixed structures, because regeneration is occurring constantly and involves diverse mother trees.

When ecological conditions change, the presence of diverse genotypes is a prerequisite for producing offspring that are able to adapt to new environmental conditions. Of the many saplings that regenerate naturally, the best adapted will survive. In contrast, nursery-reared plants are produced under artificial conditions that may favour less-adapted individuals and clones. From this we may conclude that natural regeneration ensures better adaptive capacity than planting (Pro Silva Europe, 2012). This is not to preclude plantations of exotic tree species that demonstrate the capacity to cope with changing climate conditions. Nevertheless, the planting of such species should be done cautiously and whenever possible within a matrix of natural stands.

The great uncertainty about the impact and speed of climate change requires an effective distribution of risk, which is best enabled by forests that are diversified in species and structure. Risk minimization is exactly what close-to-nature forest management has been attempting for more than a century. ◆

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The *Centre International de Sylviculture* and its historic book collection

J. Ball and W. Kollert

A collection of rare forestry books amassed in the 1930s and stored in the FAO vaults warrants greater exposure to the world.

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The *Centre International de Sylviculture* (CIS) was an initiative to establish an international forestry organization in the 1930s. Its library collection is now under the custodianship of the David Lubin Memorial Library at FAO in Rome. This article describes the establishment of the CIS, recounts the remarkable story of how the CIS collection ended up at FAO, and gives a glimpse at some of its historic books.

ESTABLISHING AN INTERNATIONAL FORESTRY CENTRE

The internationalization of modern forestry began in the late nineteenth century. Twenty-six international forestry congresses were held in Vienna from 1876 to 1914, and the International Union of Forest Research Organizations (IUFRO) was founded in 1890. Two international meetings of foresters in France, the first in 1900 in Paris and the second in 1913 in Grenoble, recommended the establishment of a permanent forestry organization (Anon., 1939). The international forest sector was represented at that time only by a section of the International Institute of Agriculture (IIA), which was founded

FAO librarian Michelle Bergerre inspects a book in the CIS historic book collection

in Rome in 1905 by the King of Italy with the intention of creating a clearinghouse for the collection of agricultural statistics. In 1930, the IIA published the first world agricultural census.

The First International Forestry Congress, organized by the IIA, was held in Rome in 1926. It set up the International Institute of Forestry, which was affiliated with the IIA, and the IIA Bureau of International Forestry Statistics was established in 1927. However, the success of these institutions was limited due to a lack of funding (Johann, 2007).

The Second International Forestry Congress was hosted by Hungary and held in Budapest in 1936 with the participation of 35 countries. Its first resolution was to consider the establishment of a permanent international forestry organization, the main aim of which would be to organize regular international forestry congresses. The Standing International Forestry Committee was set up, consisting of representatives of all 35 countries, the IIA and the IIA's *Comité International du Bois*, an international clearinghouse for information on wood technology that published statistical yearbooks on forest products and was based at that time in Vienna.

The *Centre International de Sylviculture*

The negotiations arising from the resolution of the 1936 Budapest Congress continued under the auspices of the IIA, and in March 1938 the statutes of the *Centre International de Sylviculture* (in German *Internationale Forstzentrale*) were adopted by the IIA Permanent Committee. Article I of these statutes established the CIS within the framework of the IIA and its headquarters in Berlin, Germany. The creation of the CIS benefited from the experience of Baron Giacomo Acerbo of Italy, President of the IIA, Baron Clément Waldbott of Hungary, who had been president of the Second International Forestry Congress in Budapest, and Dr Josef Nikolaus Köstler, Professor of Forest Science at the University of Göttingen. Two other countries, Finland and France, also contributed to the preparatory work for the establishment of the CIS.

The CIS consisted of a permanent secretariat in Berlin and an executive committee made up of delegates from all the CIS member countries. The first session of the executive committee was held in May 1939 in Berlin and dealt with administrative, procedural and financial matters. The CIS office and its staff were granted extraterritorial status by the Government of Germany in 1940, thus placing them above German law. The office was located in a villa in Berlin-Wannsee about 20 km southwest of Berlin.

At its first session, the executive committee elected Baron Clément Waldbott as president, Dr Köstler as director-general and Dr Georges Golay as division chief and head of the secretariat. The CIS had three divisions – on forest resources, forest techniques and forest management – and the staff was from a total of 18 European countries. The library was run by a chief librarian, who was supported by five multilingual librarians and two secretaries (Johann, 2007, 2009).

The CIS did not undertake its own scientific research, but its staff commissioned and published scientific papers of

J. BALL

The villa in Berlin-Wannsee, formerly the headquarters of the CIS, in January 2011

The oldest book in the CIS historic book collection, dated 1577

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international significance. Despite their later importance, the compilation and documentation of international literature on forestry and the establishment of a specialized international library were neither mentioned in the 1938 statutes nor foreseen in the 1939 programme or its budget.

No record has been found in the IIA archives of the invitation sent to countries or institutions to take part in the negotiations in Rome leading up to the establishment of the CIS, or to join it after it had been set up. From the composition of the participants at the first session of the executive committee, the organization appears to have consisted initially of only European countries. Mexico joined the executive committee in 1940, but there is no record of any approach being made to the United States of America, Canada or Spain, and the only record of an approach to the United Kingdom of Great Britain and Northern Ireland is a letter dated April 1940 from the Imperial Forestry Bureau in Oxford, which published *Forestry Abstracts*, evidently in response to a request from the CIS to include notices of its activities in the *Abstracts*. The Bureau curtly responded that it regretted that it was impossible to comply with the request and, moreover, that "owing to the present international difficulties" (i.e. the Second World War) the Bureau could not enter into an agreement for the exchange of the *Abstracts* for literature from the CIS. "No doubt", the letter continued, "later on conditions will be more favourable for the arrangement of an exchange agreement".

From 1939 to 1944, 19 countries were members of the CIS, although membership varied considerably over this period. For example, Latvia and Lithuania, recorded as members in 1939, disappeared from the list in 1940 because both were incorporated into the Union of Socialist Soviet Republics in August 1940 and from 1941 were occupied by Germany. Austria was never a member, having been incorporated into Germany after the 1938 *Anschluss* (annexation).

The working language of the CIS was French, presumably because French was then the international language of diplomacy. The CIS executive committee met yearly, sometimes more frequently, and reported to the annual meeting of the IIA Permanent Committee. Members of the CIS executive committee represented national governments – as they do today in international governmental forestry meetings such as FAO's Committee on Forestry and the United Nations Forum on Forests.

The publication programme of the CIS

Although its programme was reduced during the Second World War, the CIS was able to set up, at its sixth session in 1942, an international clearinghouse for information on wood technology, the *Commission Internationale du Bois* (CIB, not to be confused with the IIA's *Comité International du Bois*, mentioned earlier), also located in Berlin. The aim of the CIB was to publish the titles and keywords of all forestry publications in three languages yearly and to collect the titles in the documentation centre in Berlin. Despite the challenges of international collaboration and communication during wartime, the CIB produced a large number of publications in several languages between 1941 and 1943, including:

Schloss Emsburg today. In 1943 it became the headquarters of the CIS

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- *Intersylva*, a quarterly review published in French and German between 1941 and 1943 – the objective was to publish articles on forestry issues of international significance and to establish international networks between foresters and researchers;
- monographs published in the series *Silvae Orbis* – by 1945, twelve issues of *Silvae Orbis* had been published, with others in preparation;
- an international forestry bibliography (*Bibliographia Forestalis*), published annually from 1941 to 1943;
- economic forestry bulletins, published monthly in German and English;
- documents published from time to time on legal matters related to forestry.

THE CIS HISTORIC BOOK COLLECTION

The CIS established an international forestry library which, in 1940, subscribed to 556 technical journals through the purchase, exchange and collection of books and journals on forestry. The entire library of the Forestry Academy at Eisenach, Weimar, Germany, was purchased. The Eisenach collection consisted of 3 498 books, including 957 rare books. The libraries of the Ducal State Ministry, Gotha (about 950 books), and the Ducal Finance College, Altenburg, were also acquired, and contemporary literature was collected from these and other German institutions. In a joint venture with IUFRO, international collections of current material were formed through exchanges with libraries in, for example, Finland, France, the Netherlands, Norway, Poland, Spain and Sweden. By 1943, the CIS collection is thought to have consisted of 15 277 books and periodicals as well as 348 unpublished papers in 22 languages. It was almost certainly the largest forestry library in the world at that time.

This unique and valuable collection of historical forestry books, mainly from Germany, gives evidence of the origins of the concept of sustainability and is truly a unique treasure. The collection includes at least one hand-written document on forest management from 1577, and the others date mostly from the eighteenth and nineteenth centuries. The books are by the classic scholars of sustainable forest management, and their texts helped lay the foundation of sustainable forest and natural resource management. The concept of sustainability was first articulated in Germany by Hans Carl von Carlowitz (1645–1714), a mining administrator, who was concerned at the shortage of timber for the mining of silver ore and investigated the principles underlying the provision of regular supplies of timber essential for the industry. The CIS collection is thought to have included a copy of von Carlowitz's famous treatise *Sylvicultura oeconomica, oder haußwirthliche Nachricht und Naturmäßige Anweisung zur Wilden Baum-Zucht* of 1713 (Schmithüsen, 2013). It is feared, however, that this book was lost during the adventurous journey that the library made in the last days of the Second World War (see below).

The CIS collection also includes works of authors such as Sir Dietrich Brandis, considered by some as the father of sustainable tropical forestry, and the Bavarian forester Josef Nikolaus Köstler, the first director of the CIS. Other seminal authors whose works are in the collection are Georg Ludwig Hartig, Wilhelm Leopold Pfeil,

Heinrich Cotta, Henri-Louis du Hamel du Monceau, Johann Christian Hundeshagen, Max Robert Pressler, Johann Heinrich von Thuenen, Adam Schwappach, Friedrich Judeich and Thomas Georg Hartig. The collection also contains copies of Brehm's *Illustriertes Tierleben* (1864–1869, six volumes), essays on the physical description of the earth by Alexander von Humboldt (1847, 1849), von Humboldt's classic *Kosmos*, letters on chemistry by Justus Liebig (1859), classic economic literature by Adam Smith (*Untersuchung über die Natur und die Ursachen des Nationalreichtums*, 1794, originally published in English in 1776 as *An inquiry into the nature and causes of the wealth of nations*) and the documentation of climatic variability since 1700 by Albrecht Penck (1890, *Geographische Abhandlungen*).

The CIS in Salzburg

In December 1943, Berlin came under intense military attack and the headquarters of the CIS and its library were transferred to Schloss Embsburg in Salzburg, Austria, where it functioned as usual, although several members of the foreign staff had left. In November 1944, Dr Köstler was conscripted into the army, leaving Dr Golay, his deputy and a citizen of Switzerland, to act for him. Dr von Frauendorfer, who since 1943 had been head of the CIS library, acted as the director of the Salzburg office. In January 1945, the remainder of the archive was evacuated from Berlin to Salzburg. A makeshift convoy of vehicles was assembled for the journey from Berlin to Salzburg, each powered by producer (wood) gas prepared from a charcoal gasifier because of the shortage of petrol and diesel, with members of the staff as drivers. Dr Golay left to return to Switzerland in February 1945, and Dr Géza Luncz and Dr Richard Immel assumed his responsibilities at the CIS.

By April 1945 the theatre of war was nearing Salzburg, and the most important CIS documents were moved to Lower Bavaria in Germany, where they were stored at the Schloss Haidenburg near Aidenbach. Most of the remaining books were moved to Ramsau in Bavaria, while most of the unpublished papers and documents were stored in a mine shaft at Wolf Dietrich Stollen, Hallein, near Salzburg.

The material held by the CIB was not evacuated from Berlin, and unfortunately most of it was destroyed in the fighting near the end of the war. Only about 600 books survived the bombs; they were removed by the British army and transported to Hamburg in 1946 and subsequently to London. It is possible that they were sent to the then Timber Research and Development Authority at Princes Risborough in England, but that library subsequently closed and the contents were sent to the Building Research Establishment at Watford. That institution, too, closed in about 2005 and at least some of the collection was taken to the Radcliffe Science Library in Oxford in 2010 (R. Mills, personal communication, 2010). It is unclear whether any of the original CIB documents survive today.

THE POST-WAR PERIOD

The post-war work of the CIS at Embsburg consisted of maintaining the library and reassembling the collection. Dr von Frauendorfer was responsible for tracking

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Books in the CIS historic book collection

down missing documents in the second half of 1945 and in 1946. He was only partially successful in this because parts of the collection had been lost in the chaotic conditions of its dispersal. He is reported to have recovered 16 boxes of documents.

The integrity of the headquarters of the CIS in Salzburg was fully respected by the American troops, into whose zone it fell after the war, but recognition of its international extraterritorial status was not granted. Nevertheless, the American military government and authorities gave high priority to the maintenance of the CIS and its book collection and agreed to pay the costs of maintaining the offices and the salaries of existing staff and three new staff members from mid-October 1945. The military government also agreed to the eventual incorporation of the CIS into the framework of the newly established United Nations specialized agency, FAO. Based on a resolution of the 16th General Assembly of the IIA, which convened in Rome on 8–9 July 1946, the CIS was dissolved and its functions and assets integrated into FAO.

As a result of consultations between FAO (then based in Washington, DC) and CIS staff, the book collection was moved from Salzburg to the European office of FAO in Geneva, where a note in the CIS archives states that it was located in 1948. From there it was moved to the IIA in Rome and then to FAO when its headquarters were transferred to Rome in 1951.

FAO's David Lubin Memorial Library remains the home of the approximately 11 000 forestry-related books and journals in 21 languages salvaged from the CIS's original library. To a large extent, the value of this historic collection has been overlooked, perhaps because it is uncatalogued and therefore not easily accessible. In recent years, only Rubner (1997), Steinsiek (2008) and Johann (2009) have mentioned its existence in published papers. In 2007, Dr Elisabeth Johann carried out an assessment, evaluation and partial cataloguing of the collection of old forestry books in German, which was followed by an exhibition of rare books at the 18th session of the Committee on Forestry held at FAO headquarters in Rome in 2007.

THE SIGNIFICANCE AND FUTURE OF THE COLLECTION

The CIS is important as the world's first international forestry organization (as opposed to a forest research organization such as IUFRO). It collected and disseminated publications in several languages and anticipated the role of FAO in forestry data collection and analysis by a decade. The history of the CIS, outlined here, shows that international cooperation within the scientific and forestry community began in the 1930s and continued even during the Second World War. Due to the war,

The CIS historic book collection is housed securely in a controlled and fire-protected environment at FAO

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however, the CIS could not meet the high expectations of its founding members, in particular in the organization of international congresses and the development of international conventions related to forestry.

The legacy of the CIS is its surviving library collection, which contains materials published by the CIS and acquired by it. A considerable number of the books in the collection are valuable because of their age and rarity. Many are by famous authors and stem from the dawn of forestry as a science; arguably, some form the origin of the concept of sustainability. Others have continuing scientific value, and yet others are valuable for their artwork, containing beautiful illustrations and copperplate prints of plants and animals. Some are first editions and possibly the only remaining copies of ground-breaking documents (Johann, 2007, 2009). The books bear witness to an era in which traditional forest-related knowledge gained from field experience was replaced or complemented by the results and findings of scientific observations, and they also reflect the social and cultural values of earlier centuries. In short, the collection documents the world's first science-based attempts to sustainably manage renewable resources. It is an invaluable resource, not only for forest historians but also for those researching the development of the concept of sustainability and the origins of sustainable forest management.

Considering the extraordinary history of the books, the collection is in very good condition. It is housed securely in a controlled and fire-protected environment at FAO. Visiting researchers can gain access to it on request to the FAO David Lubin Memorial Library, Rome.

Making this important collection of books accessible to a wider audience in digital form would accord with FAO's mandate to disseminate information and knowledge. The cataloguing of the collection, which Dr Johann began in 2007, must be completed to comprehend its scope and content, after which indexing and digitization of some of the more important volumes would allow universal online access and ensure that the collection has an enduring benefit for the global forestry community, well beyond the monetary value of the collection.

An online exhibition of some items in the CIS collection can be accessed at: http://www.flickr.com/photos/73428043@N00/sets/72157603275242277/.

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Is SFM an impossible dream?

A. Sarre and C. Sabogal

The implementation of SFM, in its various guises, has been patchy.

Forestry can make a strong case as the first profession to articulate the concept of sustainability and to apply science towards its attainment, yet sustainable forest management (SFM) is still not being applied universally today. In this article we ask why. We examine what is meant by the term SFM in the modern context and how its meaning continues to change. We attempt to quantify the minimum extent of its application, and we examine the obstacles that lie in its way, especially in the tropics, where they are greatest.

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A researcher inspects a tree in the Yoko Forest, the Democratic Republic of the Congo

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Forests will always be subject to perturbations, such as this forest in Grenada, which was devastated by Hurricane Ivan in 2006. A sustainably managed forest has the resilience to withstand disturbances and the capacity to adapt to longer-term environmental changes

DEFINING SFM

While the concept of forest sustainability might be relatively old (Schmithüsen, 2013), the term "sustainable forest management" is not[1], at least in English. It was absent from Westoby's *Introduction to world forestry*, published in 1989, but present in the International Tropical Timber Organization's *Guidelines for the sustainable management of natural tropical forests*, published in 1990 (ITTO, 1990), and in the Forest Principles agreed at the 1992 Earth Summit. The term emerged in common use in parallel with "sustainable development", defined by the World Commission on Environment and Development (1987) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". One of the definitions of SFM is the management of forests according to the principles of sustainable development.

The SFM concept has proved elusive. In 2007, member countries of the United Nations Forum on Forests agreed on the Non-legally Binding Instrument on All Types of Forests (NLBI). In that document, SFM is described as:

> *a dynamic and evolving concept [that] aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations.*

This is not a definition but a statement of intent: it makes clear that SFM will change over time but that its purpose, at a minimum, is to maintain all forest values in perpetuity. Turning the SFM concept into practice in a given forest management unit is demanding because it requires setting and attempting to achieve (often multiple) objectives in a milieu of multiple stakeholders, dynamic environmental, economic and social conditions and imperfect ecological knowledge. SFM becomes even more complex when scaled up to the landscape, subnational and national levels.

Drawing on the criteria identified by various international forest-related criteria and indicators processes, the NLBI sets out seven thematic elements of SFM "as a reference framework for sustainable forest management". They are: the extent of forest resources; forest biological diversity; forest health and vitality; productive functions of forest resources; protective functions of forest resources; socio-economic functions of forests; and the legal, policy and institutional framework. Collectively, these elements, and the criteria and indicators that underlie them, may be thought of as providing categories of "values" that should be monitored and maintained. To a certain extent, they underpin forest certification, which is discussed later.

Forests will always be subject to perturbations, but a sustainably managed forest has the resilience to withstand them and the capacity to adapt to longer-term environmental changes. Nevertheless, a forest that is sustainably managed today could be cleared tomorrow if the owner has a change of heart, or it might die or degrade quickly if environmental (e.g. the climate) or social conditions suddenly change. The task of

[1] Or its common use is relatively new.

A member of a community council holds honey collected in a community forest area in Chhouk District, Kampot Province, Cambodia. Local involvement in decision-making is essential for SFM

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managing forests so that its values are maintained is a tall order, especially given inherent uncertainties: some might say it is an idealistic – and unrealistic – dream.

Society decides

In a survey of 28 forest management case studies in the Asia and Pacific region, Brown, Durst and Enters (2005) found that the fundamental principle in the pursuit of SFM was reaching societal consensus with regard to how forests should be managed and what a society wants from forests. The scale at which such consensus should be reached – community, subnational, national or global – will vary depending on the scale and nature of the resource.

Sustainability has four dimensions – economic, environmental, social and cultural[2] – that involve tradeoffs, but quantifying these is not always easy. To some extent, the economic and environmental dimensions can be assessed, but not necessarily using comparable measures by which tradeoffs can be optimized. Science, therefore, can only make a limited contribution to defining in practice the goals of SFM in a given context. Decisions on forests – and on the goals of SFM in a given context – should be made, therefore, through informed, broad-based, participatory and democratic processes. The forestry profession has made considerable progress in developing participatory models of natural resource management and could be said to have been a leader in such efforts through, for example, the social forestry and community forestry models that developed especially from the 1980s. Experience has shown that such processes can be unwieldy, long-winded and expensive, but that they are essential for SFM.

Forest multifunctionality

What issues might a society consider in deciding the objectives of SFM? Three hundred years ago, when forest science first began to blossom (Westoby, 1989), forestry was concerned predominantly with the sustainability of wood supply (Schmithüsen, 2013). Since then, the concept of SFM has broadened sufficiently to embrace virtually any forest-based objective, including the management of forests in which no products (or only non-wood products) are harvested – forests usually known as protection or conservation forests. In many contemporary societies, SFM is expected to ensure that neither biodiversity nor carbon stocks

[2] The cultural dimension may be viewed as part of the social dimension, however. United Nations General Assembly (2012) referred to the "three dimensions of sustainable development" but also acknowledged that democracy, good governance and the rule of law, at the national and international levels, as well as an enabling environment, are essential for sustainable development.

diminish over time, that the quality of water issuing from forests is perpetually high, that recreational pursuits are catered for, that the cultural heritage embodied by forests is respected, that people who have relied traditionally on forests for their livelihoods can continue to do so, that products needed or desired by society are supplied in sufficient volume with no diminution in productivity, that conflicts over the use of forests are managed in a fair and transparent way, and that the wider landscape benefits from it. This is known as managing for the multiple functions ("multifunctionality") of forests (Collaborative Partnership on Forests, 2012). Arguably, no other land use is required to meet so many simultaneous and dynamically changing objectives.

Forest management commonly falls short of the expectation that it can fully maintain all forest values at all times. In practice, however, not all forest areas can (or should) be managed for all values, although management should aim to minimize losses. Multifunctionality is best considered at a scale large enough to include a mosaic of areas in which SFM may have specialized objectives but which, in aggregate, delivers on all forest functions. While SFM should always be the goal of managers, the most that can be said at any given time is that forest management should be consistent with the concept of sustainability and the associated management objectives that are in place (ITTO, 2006). SFM should be envisaged as a co-evolutionary process between changing societal demands, changing forests, changing markets and changing industry efficiency (Nasi, 2013).

ASSESSING SFM

Despite the many difficulties associated with the concept of SFM, the management of many forests today is consistent with it. Some forests have been managed for more than one hundred years (see, for example, Küchli, 2013); while it cannot be said definitively that such forests are under SFM, the fact that they are still productive is prima facie evidence of this.

Certification as a proxy

Forest certification can be described as a process whereby an independent auditing (third party) body conducts an inspection and awards a certificate using independently developed standards and objectives (FAO, undated). According to Molnar (2003), governments and international policy-makers, including multilateral financial institutions, promote forest certification for its political and regulatory value and "as a credible and cost-effective proxy to indicate that a forest or industry is sustainably managed".

This use of forest certification as a proxy measure of SFM is flawed, yet to date there is no better survey for judging the state of forest management globally. Here, therefore, the area of certified forest is used as a proxy assessment of the *minimum* area of forest in which management is consistent with SFM.[3]

Table 1 shows that, worldwide, the total forest area certified under the two dominant global certification schemes, the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC), is about 415 million hectares (ha). According to FAO (2010), there are about 4.03 billion ha of forest globally. Therefore, using certification as a proxy, a minimum of 10.3 percent of all forests is under management that could be considered consistent with SFM. FAO (2010) estimated that 54 percent of the total forest estate (about 2.18 billion ha) was designated for production or "multiple use" in 2010.[4] Therefore, about 19 percent of forests in which timber harvesting is likely to be allowed are certified.

This estimate comes with important caveats, including the following:

- The estimate is for a *minimum* area of forest under management that is consistent with SFM, because a large area of forest that has not been certified (for example, where managers see no commercial advantage in attaining certification, or where the cost of certification is probably greater than the benefit) is likely to be managed as well or better than many certified forests.
- The pursuit of certification makes more financial sense in forests where the harvested timber is to be sold into markets where certification is a prerequisite for doing business or provides some other market advantage. Relative to temperate forests, only a small proportion of the timber harvested in the tropics is sold into such markets, so it might be expected that certification would be pursued less often there.
- Certification is usually applied to forests subject to harvesting, mostly for timber. Therefore, a very large area of protection/conservation forests, and forests otherwise not subject to timber harvesting, are not included in the survey. In Australia, for example, only about 113 million ha of the 149 million ha of forest countrywide are legally available for wood harvesting, and much of that area contributes little to wood supply (Montreal Process Implementation Group for Australia, 2008).
- Not everyone agrees that certification is a good indicator of management that is consistent with SFM. For example, standards of certification, even within the same scheme, may vary widely among (and even within) countries. Auld, Gulbrandsen and McDermott (2008) noted scepticism that certification can assist in achieving forest conservation goals at the landscape level. Zimmerman and Kormos (2012) claimed that "industrial-scale" forest management (of which some examples are certified) "guarantees the commercial and biological depletion of high-value timber species within three

[3] However, the Forest Stewardship Council, a major certification body, uses terms such as "responsible management" and "environmentally appropriate, socially beneficial, and economically viable management" rather than SFM.

[4] The remainder was designated for the protection of soil and water, the conservation of biodiversity, social services, "other", or "none or unknown".

harvest rotations in all three major tropical forest regions".

Less progress in the tropics

Given that the forest certification concept arose only in the early 1990s (the FSC, the world's first forest certification body, was established in 1993), the fact that about one-fifth of the world's production and multiple-use forests are certified is a considerable and laudable achievement. As a number of authors have pointed out (e.g. Auld, Gulbrandsen and McDermott, 2008), however, the distribution of certified forests is very uneven. Table 1 shows that 384 million ha of the 415 million ha of certified forest are located in temperate, mostly developed countries – Australia, Chile, New Zealand, Republic of Korea, United States of America and the countries of Europe. Only 31 million ha are in developing (mostly tropical) countries; this is equivalent to only 1.9 percent of the total forest estate in developing countries.

Blaser *et al*. (2011) reported on the extent of SFM in 33 tropical countries that account for about 85 percent of the world's closed tropical forests and 35 percent of all forests worldwide. Focusing on the "permanent forest estate" (PFE, defined as "land, whether public or private, secured by law and kept under permanent forest cover"), they estimated the area of natural forest under SFM in 2010 at 53.3 million ha, comprising 30.6 million ha of production PFE and 22.7 million ha of protection PFE. This was about 7 percent of the total PFE.

Although the data are patchy, the survey by Blaser *et al*. (2011) and the data on forest certification (admittedly subject to a number of important caveats) are sufficient to show that SFM is less established in the tropics than in the temperate zone (nevertheless, there is evidence that SFM can be applied successfully in the tropics – see box). What is holding it back? While the following discussion focuses on some of the obstacles to SFM in the tropics, this should not be taken to imply that the situation is always rosy elsewhere.

TABLE 1. Global area of forest certified by FSC and PEFC, 2012

Country	Area of forest ('000 ha) certified by:		Total area of certified forest ('000 ha)	Total area of forest ('000 ha)	% of total forest certified
	FSC	PEFC			
Argentina	305	0	305	29 400	1.0
Australia	895	10 100	10 995	149 300	7.4
Belize	170	0	170	1 393	12.2
Bolivia (Plurinational State of)	1 270	0	1 270	57 196	2.2
Brazil	7 200	1 230	8 430	519 522	1.6
Cameroon	728	0	728	19 916	3.7
Canada	54 300	109 000	163 300	310 134	52.7
Chile	508	1 910	2 418	16 231	14.9
China	2 520	0	2 520	206 861	1.2
Colombia	94	0	94	60 499	0.2
Congo	2 480	0	2 480	22 411	11.1
Costa Rica	41	0	41	2 605	1.6
Ecuador	54	0	54	9 865	0.5
Europe*	72 900	83 500	156 400	998 370	15.7
Gabon	1 879	0	1 879	22 000	8.5
Ghana	2	0	2	4 940	0.0
Guatemala	502	0	502	3 657	13.7
Honduras	153	0	153	5 192	2.9
India	40	0	40	68 434	0.1
Indonesia	1 450	0	1 450	94 432	1.5
Japan	397	0	397	24 976	1.6
Kenya	1	0	1	3 467	0.0
Republic of Korea	371	0	371	6 222	6.0
Lao People's Democratic Republic	83	0	83	15 751	0.5
Madagascar	1	0	1	12 553	0.0
Malaysia	504	4 590	5 094	20 456	24.9
Mexico	601	0	601	64 802	0.9
Mozambique	5	0	5	39 022	0.0
Namibia	275	0	275	7 290	3.8
Nepal	14	0	14	3 636	0.4
New Zealand	1 452	0	1 452	8 269	17.6
Nicaragua	22	0	22	3 114	0.7
Panama	14	0	14	3 251	0.4
Papua New Guinea	33	0	33	28 726	0.1
Paraguay	19	0	19	17 582	0.1
Peru	818	0	818	67 992	1.2
Solomon Islands	64	0	64	2 213	2.9
South Africa	1 552	0	1 552	9 241	16.8
Sri Lanka	32	0	32	1 860	1.7
Suriname	89	0	89	14 758	0.6
Swaziland	80	0	80	563	14.2
United Republic of Tanzania	113	0	113	33 428	0.3
Thailand	24	0	24	18 972	0.1
Turkey	95	0	95	11 334	0.8
Uganda	107	0	107	2 988	3.6
United States of America	14 100	35 300	49 400	304 022	16.2
Uruguay	836	0	836	1 744	47.9
Venezuela (Bolivarian Republic of)	140	0	140	46 275	0.3
Viet Nam	45	0	45	13 797	0.3
Total	**169 378**	**245 630**	**415 008**	**3 390 662**	**12.2**

Notes: FSC data current as of November 2012; PEFC data current as of 13 November 2012; * "Europe" comprises Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, the Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom of Great Britain and Northern Ireland. The five European countries with the most certified forests are the Russian Federation (33.7 m ha), Sweden (22.1 m ha), Finland (21.5 m ha), Belarus (13.1 m ha) and Norway (9.38 m ha).

Sources: FSC, 2012; PEFC, 2012; FAO, 2010.

Biodiversity – obstacle and asset. A butterfly feeds on a flower in Ecuador

FAO/R. FAIDUTTI/CFU000782

OBSTACLES IN THE TROPICS

Less is known about tropical forests. In Europe in particular, forest science has a 300-year history, and the practice of SFM is well advanced. Forest science has had a more chequered history in the tropics. In general, the primary concern of colonial forest services was the supply of timber; rarely were resources devoted specifically to learning how tropical forest ecosystems might be managed on a sustainable basis (Westoby, 1989). While much research of this type has been conducted in the last several decades, there is still plenty to learn and apply. On the other hand, a great deal of traditional knowledge and practices held by customary owners, which ensured certain levels of resource sustainability, is yet to be incorporated into modern forest management systems (Tongkul *et al*., 2013).

After the Second World War, many foresters in the newly independent countries of the tropics were well-trained in classical forestry but less so, perhaps, in dealing with "the real forestry problems confronting their own people" (Westoby, 1989). Many broad social issues with profound implications for tropical forests – such as poverty, the quest for agricultural land, the duality of land tenure, and ethnic conflicts – could not be solved by foresters alone, and institutional capacity to tackle such issues was lacking. This lack of attention to social issues could be said to be a common failing of classical forestry, one that was identified by Westoby (1987), and by Poore *et al*. (1989) in the tropics. It remains a challenge for the forestry profession today and requires much stronger intersectoral cooperation.

High levels of biodiversity. Maintaining a high level of biodiversity, such as that found in natural tropical closed forests, complicates the silviculture and management of SFM.[5] It can also compromise the profitability of timber harvesting under an SFM regime because the density of marketable species is often low. Considerable effort has been made to increase the marketability of diverse tropical forest tree species – often called lesser-used species –with only limited success (e.g. Rivera *et al*., 2003; Pederson and Desclos, 2005). Silvicultural efforts to increase the density of commercially valuable species may compromise the maintenance of biodiversity. On the other hand, the increased use of lesser-used species would enable the more intensive – but potentially sustainable – use of mixed tropical forests, with the effect that less forest overall would be subject to harvesting. Such intensive use is the norm in the often lower-diversity temperate forests.

Unresolved tenure disputes. A lack of clarity on forest ownership, and injustices in the allocation of rights over forests, are major obstacles to SFM. For example, the Government of Liberia (2008) reported that "the most pressing issue affecting all land use in Liberia is the lack of legal clarity over property ownership and use rights. ... Rights of access to and use of

[5] It also complicates their management in a broader sense because it can lead to increased legal restrictions and brings a wide range of cultural issues and the close scrutiny of conservationists, which may or may not be obstacles to good management.

natural resources, including land, minerals, forests and water, are shrouded in a state of tenure insecurity, vague and ambiguous legislation, conflicting and competing tenure arrangements, and constant and persistent clashes of customary and statutory rights over the management, authority and control of these resources".[6] This is a problem in many parts of the tropics, although significant reforms have been achieved in some countries and reform processes are under way in some others (Rights and Resources Initiative, 2013).

Corruption. Corruption can be a major hindrance to SFM because it hampers the enforcement of forest-related laws. Cerutti *et al*. (2012), for example, describe corrupt practices in the small-scale logging sector in Cameroon, which arose partly as a result of poor policy decisions made in 1999 (to suspend small-scale logging licences) and in 2006 (to centralize the allocation of such licences, when the suspension was lifted). Cerutti *et al*. (2012) showed that corruption was systemic and that a small number of officials actively perpetuated it because it served their interests. This is having "rippling negative effects that extend from the morale and professional performance of state officials to the efficacy of state institutions" and undoubtedly reduces the likelihood of SFM.

Uncompetitiveness of SFM as a land use. Appanah (2013) suggested that the quest for quick profits was one of the main reasons why adequate silviculture has been rare in the natural forests of Southeast Asia. Pearce, Putz and Vanclay (2003) reviewed evidence and arguments for the viability and desirability of SFM in the natural tropical forests and found that forest companies should not be expected to adopt it without additional incentives to improve its profitability. High transaction costs for timber and (even more so) non-timber forest products due to inefficient and sometimes corrupt legal, institutional and administrative arrangements also act to reduce profitability. Given current prices for most tropical timbers (kept low, at least in some markets, in part by the availability of illegally harvested wood) and the low density of marketable species, timber alone is rarely sufficient to make SFM competitive with other land uses. This is perhaps the fundamental obstacle to the pursuit of SFM, at least in moist tropical forests: the land occupied by forests has other uses that many landholders (community, state and private) perceive to be more in their interests. When the land on which forests stand is seen to be more valuable than the trees and other biodiversity on it, the forest inevitably disappears.

[6] A law was passed in Liberia in 2009 aimed at addressing this lack of clarity, but tensions over land-grabbing persist there and elsewhere (Rights and Resources Initiative, 2013).

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Land-use change from tropical rainforests to rubber or oil-palm plantations, Peninsular Malaysia. When the land on which forests stand is seen to be more valuable than the trees and other biodiversity on it, the forest inevitably disappears

FAO/C. SABOGAL

A forest harvesting operation in the Amazon using reduced impact logging

PREREQUISITES FOR SFM

Douglas and Simula (2010) suggested that bringing about SFM required linking finance and capital with natural forest systems, and with ongoing human interactions with those systems, to shift the dynamic towards sustainability. In other words, tropical forest management must become more profitable. This may involve better prices for timber and non-timber products, greater use of currently unmarketable species, payments for ecosystem services, subsidies, or some other financing mechanism. In our view, the following are also necessary:

- competent institutions at all levels (community, subnational and national);
- clarity on tenure and the resolution of tenure conflict;
- the use of participatory, democratic management models to define the objectives of SFM at various scales and enable the participation of stakeholders in management and the equitable sharing of benefits and costs;
- efforts to convince users of the advantages of SFM practices – such as greater efficiency, better working conditions and less long-term risk;
- capacity and institution strengthening at the local level coupled with adequate and timely information and effective technical and extension support services;
- the continued development of silvicultural approaches to maintain, increase or restore vital ecological functions, including productivity and regeneration capacity;
- much greater interorganizational and intersectoral cooperation to ensure the maintenance of forest values at the landscape scale;
- effective monitoring and evaluation of forest management to enable the adaptation of management as circumstances and expectations change;
- at the national scale, the political will to encourage SFM through tenurial, institutional, regulatory and market reforms and the provision of incentives to compensate landholders for the ecosystem services they provide.

As they grow economically and achieve further institutional improvements, many tropical countries are likely to make incremental progress in all or most of the above areas in coming years, and, globally, forest management will become more consistent with SFM principles over time. The world's rich could expedite the process by helping to increase the financial viability of SFM, such as through payments for locally-to-globally important ecosystem services.

CONCLUSION

SFM is not just an idealistic dream: it embodies a process that is the best bet we have for maintaining and increasing the contributions of forests to global

Exemplary cases of SFM

FAO has compiled and documented almost 80 cases of successful SFM in action, demonstrating the economic, social and environmental benefits that can be achieved under SFM. Using varied approaches and strategies in multiple contexts, these examples show that good forest management is a powerful conservation practice that can reduce deforestation and maintain ecosystem services, and that it is a potent development option that can help reduce rural poverty and improve living conditions.

The FAO initiative, called *In search of excellence: exemplary cases of sustainable forest management*, sought to: identify a broad cross-section of exemplary forest management in Central Africa (FAO, 2003), Asia and the Pacific (Durst *et al.*, 2005), and Latin America and the Caribbean (Sabogal and Casaza, 2010); showcase forest management efforts that display promise for the future; and highlight examples across a variety of forest types and ecosystems from many countries in the tropical regions.

well-being. The risks posed by resource degradation and depletion and by climate change make SFM imperative; more than ever, humanity will need the products and ecosystem services provided by forests (Blaser and Gregersen, 2013). Undoubtedly, given its dynamic nature, the SFM concept will continue to be debated, but we should not allow its ambiguity to slow our ground-level pursuit of it. ◆

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The search for a viable silviculture in Asia's natural tropical forests

S. Appanah

Natural forest silviculture could work in South and Southeast Asia – but only if pressures to overharvest and deforest ease.

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Sustainable forest management (SFM) is an evolving process; it always has been and always will be. It has changed as society's views and needs have changed and as knowledge of forest ecosystems has improved. It has also been influenced strongly by ownership. In many parts of the world, most recently in the tropics, forest ownership shifted from local people and customary systems to the state, and now there are societal pressures – and considerable impetus – to revert to local ownership or use rights, with often profound implications for forest management. As several authors in this edition of *Unasylva* point out, therefore, SFM is about much more than a silvicultural system: it encompasses a wide range of environmental and socio-economic issues as well. A scientifically perfect silvicultural system may not be implemented if the social settings – such as a lack of involvement of local people in management – do not support its implementation, there is a sudden change in environmental

Profuse regeneration in a tropical lowland rainforest, Sabah, Malaysia

M. KLEINE

conditions, or the practices applied are economically unviable.

The notion of forest conservation has existed in the Asian tropics for thousands of years, and modern silvicultural systems have been in place in some areas for more than 100 years. Yet SFM is still relatively rare. This article reviews historical approaches to forest management in the moist tropics of Asia and the silvicultural systems in use in the region. And it discusses what is needed for their widespread success.

A future-harvest tree marked for retention in a lowland tropical rainforest managed for timber

M. KLEINE

MANAGEMENT SYSTEMS

Indigenous management systems

While people have lived in tropical forests for tens of thousands of years, their traditional activities barely made a dent on forest area – perhaps unsurprisingly, given the generally low population pressures – and may have even promoted forest diversity (Baker, Wilson and Gara, 1999). Forest-dependent indigenous people practised shifting agriculture (rotational farming) – usually sustainably, thanks to long fallows (about 40 years, compared with current practices of often less than eight years), and they also harvested forest products and game. Early cultures developed low-intensity practices such as the cultivation and protection of fruit trees like mango and durian (in South and Southeast Asia), and avocado and Brazil nut (in South and Central America). Traditional forest-dwellers in Asia rarely cut the largest trees, preferring to use small poles, vines and bamboo for their houses and most other construction needs.[1] Some cultures developed more intensive forest management practices, such as the "firestick farming" employed by Australian Aborigines, to manage their food resources (Jones, 1969), which sometimes had major influences on forests, landscapes and biodiversity.

When forest management was taken over by the state, however, indigenous peoples were often blamed for forest destruction, their needs were ignored, they were evicted from forest reserves and they usually missed out on the benefits of forest development.

Ancient civilizations

As human populations grew and agriculture expanded, forests became overexploited. The Roman Empire is often cited as an example of how, with its expansion, forests went into decline. The Romans failed to institute conservation measures and, when timber became scarce locally, they simply met their needs by importing from foreign territories. Several authors (e.g. Diamond, 2005) have suggested that the historical decline of some civilizations was closely linked to the destruction of forests and the subsequent shortage of wood and decrease in ecosystem services, and to the failure to adapt to such changes.

Some societies, however, were able to address overexploitation in time. They instituted rules and regulations to control tree harvesting, grazing and the collection of non-wood forest products. In Asia, India stands out as a well-researched case

[1] Heavy hardwoods such as iron wood (*Eusideroxylon zwageri*) and teak (*Tectona grandis*) were sometimes cut for special purposes like the building of temples, palaces, long houses and dugout boats.

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This natural regeneration will form a future tree crop in a harvested lowland tropical rainforest

(e.g. Kumar, 2008). The concepts of sustainable management and conservation were embedded in the religious ethos of the region as far back as the Vedic period (4 500–1 800 Before the Common Era). Religious texts (*aranyakas*, or forest works) contain descriptions of uses and management of forests, the need to maintain forests for the "wholeness" of villages, participatory forest management and the creation of sacred forests and groves as part of cultural landscapes. Another well-recorded case in Asia is Japan, and there were many other examples in ancient Asia. Nevertheless, with the growth of populations and increases in commerce and industrial development in the seventeenth century, forest resources declined rapidly.

Advent of scientific forest management

India also provides an excellent example of the origins of scientific forest management in the tropics, so much so that the system there is referred to as "classical tropical forest management". During the early British occupation, forests appeared inexhaustible and were harvested with little control to meet demand for materials for ship-building in Britain, India's railroad expansion and other requirements. By the early 1800s, the teak forests of Malabar (South India) had been destroyed, and similar reports of forest devastation were filtering in from Tenasserim province in Burma (now Myanmar).

Such widespread forest damage provided the impetus for forestry pioneers such as Dietrich Brandis to introduce to India approaches that had been developed in Europe (Schmithüsen, 2013). While the approaches were imported, these pioneers recognized the complexity of tropical forests and, through analysis and research, progressively developed methods to suit local geographical and social settings (Leslie, 1989). The basic management elements of this scientific and iterative approach were: taking over the authority to manage forest areas; formalizing ownership and rights, including customary rights; determining the extent of the forest estate; investigating the silviculture of the main timber species; determining growth rates and investigating how to generate more precise inventory measurements; and developing sustained-yield management regimes that included yield control and the replenishment of harvested areas.

FOREST MANAGEMENT SYSTEMS FOR TROPICAL FORESTS

The early experiences in India resulted in several new forest management regimes, developed to accommodate variations in climatic, edaphic and physiographic features and human–forest interactions. The main components of these management systems were silvicultural and addressed the harvesting of trees, the regeneration of harvested areas, and the tending of regeneration to maturity. Two of the most well-developed silvicultural systems, the selection and shelterwood systems, are described below.

Heavily logged-over dipterocarp forest: the often high level of logging damage has made it difficult to determine the success of silvicultural approaches

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Selection systems

Selection systems are the most prevalent form of silviculture in natural moist tropical forests in Southeast Asia. When the proportion of valuable species is low, trees of these species are felled selectively over a large area at periodic intervals. Areas that come under the system are called the selection working circle. Under this polycyclic selection system, exploitable trees of a specific girth are harvested and the next cutting cycle is determined by the time taken for the pre-exploitable class to reach harvestable size. The length of the felling cycle varies from 15 to 45 years, depending on the region and species. The system assumes that the selective removal of harvestable trees and the presence of pre-exploitable trees will provide the right environment for the establishment and growth of new regeneration. Some gap-planting may be undertaken where natural regeneration is poor.

Shelterwood systems

Shelterwood systems were introduced when the demand for wood increased and regeneration was not assured. The system involves the removal of the old stand through a series of cuttings so that regeneration produces a new, even-aged stand. Two variants of the shelterwood system have been broadly employed in India: the irregular shelterwood system and the uniform system. The irregular shelterwood system is used when regeneration is uncertain. Trees above the minimum exploitable diameter are removed, although mother trees are kept if there is a lack of regeneration. Additional regeneration improvement cuts are undertaken until regeneration is established, over a rotation of about 120 years.

The uniform system has been tried in high-value sal (*Shorea robusta*) and teak (*Tectona grandis*) forests. All exploitable timber is removed in one felling and regeneration is allowed to grow up. Where regeneration is poor, artificial regeneration techniques are employed. The rotations should be between 120 and 180 years, although they have become shorter as timber demand has increased.

Spread of Indian systems

The experiences in India were subsequently transferred and adapted to other British colonies in the tropics. The development of forest management systems in Peninsular Malaysia in the early 1900s demonstrates clearly the paths taken to deal with the issue of sustainability. Prior to introducing forest management, logging in Peninsular Malaysia was selective and focused on the heavy hardwoods, and silvicultural operations were limited to enrichment planting. But with the increase in timber demand, improvement fellings were carried out to release immature trees of valuable species. The approach did not bring about the intended result, but young regeneration became profuse. This led to

the development of regeneration improvement fellings, in which commercially inferior species were removed in a series of fellings. Once the regeneration was verified as meeting requirements, a final felling of exploitable trees was carried out.

A serendipitous discovery led to the development of the Malayan uniform system (Wyatt-Smith, 1963). During the Japanese Occupation (1942 to 1945), many forests in Malaya (now Peninsular Malaysia) were clearfelled without applying systematic regeneration fellings. Later surveys revealed that these forests contained profuse regeneration, thus giving rise to the Malayan uniform system. Under this system, if adequate regeneration is present, a single felling is used to release the fast-growing dipterocarp seedlings and saplings to form a high stocking of a uniform future commercial crop. This approach was the basis for managing lowland dipterocarp forests from the late 1940s.

In the mid-1970s when the lowland dipterocarp forests in Malaysia were mainly alienated for extensive agricultural programmes, forestry was relegated to hillier sites, where natural regeneration was not uniformly present. A simplified version of the Philippines selective logging system was adopted (Appanah and Weinland, 1990), under which all commercial species of specific girth were harvested, with a sufficient number of pre-exploitable trees retained to form the next cut in around 30 years. An adequate stock of seedlings is assumed to exist, or will be replenished by the residual trees retained for the next crop. Selective fellings used for mixed dipterocarp forests in Indonesia and the Philippines, which preceded the selective fellings employed in Peninsular Malaysia, relied on the same principle: cutting exploitable individuals and leaving behind an adequate number of residual trees, which then provided stems for the next cut, which was carried out in cycles of about 30 years.

HOW SUCCESSFUL HAVE THESE SILVICULTURAL SYSTEMS BEEN?

After almost a century and a half of modern management in tropical forests, are there lessons to be learned? While the "scientific" silvicultural systems described above originated in Western Europe, they were adapted to new climatic conditions and high tree diversity.

Despite the lengthy period of trials, revisions and change, however, the success of these systems remains tentative. There are inherent difficulties in all these systems and they have often been applied imperfectly. The selection system, which exploits mature timber in cycles of 30–40 years and relies on pre-exploitable trees to form the future harvest, appeals to most practitioners. It does not, however, take into account the severe logging damage often inflicted by a combination of heavy harvesting machinery and poor harvesting planning and techniques (Nicholson, 1979; Appanah and Weinland, 1990). Surveys have revealed a lack of pre-exploitable trees nearly two decades after the first logging, which will mean a reduction in the number of harvestable, valuable trees at the next cut. With technological developments, many previously undesirable or lesser known species have increased in commercial value, or may do so in the future (Freezailah, 1984). But the lack of attention to regeneration in selection systems means that a lack of continuity of timber production is likely, if not inevitable.

In contrast, shelterwood systems, which focus on regeneration, have greater potential to provide continuity for future crops. Forest departments seem unwilling, however, to wait for the maturation of harvestable trees in shelterwood rotations, which can take 60 years or more. In the last few decades, as the demand for timber increased in South and Southeast Asia, especially as export markets expanded,

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Silvicultural tending operations in dipterocarp forests: this is indispensable for sustainable production in tropical forests

extraction clearly overwhelmed natural production capacity. As a consequence, overharvesting has placed extreme stress on the viability of these nascent forest management systems.

Selection systems provide timber in the short term, with no guarantee of sustainability. Shelterwood systems have a built-in mechanism for sustainability but so far have proved too demanding in terms of silvicultural interventions and are unpopular with practitioners with short-term goals.

THE POTENTIAL FOR SFM IN TROPICAL ASIAN FORESTS

Forest management is of course more than (and in some cases may not even involve) achieving a sustainable timber yield: it is a continuous pursuit to meet ever-changing and increasingly varied needs. While foresters argue over which silvicultural system is best, external factors may render such arguments academic. Forests in Southeast Asia face intense competition from agriculture, and there is much controversy over replacing timber-rich dipterocarp forests with oil-palm plantations. SFM is yet to demonstrate that it is financially competitive as a land use compared with cash-crop plantations.

In steeper terrain, SFM is arguably the best form of land use because forests provide important services related to the protection of water catchments and soil, biodiversity conservation and other environmental benefits that agriculture and urban settlements take for granted (and cannot match). But the provision of such services has not yet been factored into land-use planning in many countries, and land conversion for agriculture continues relentlessly. It has been argued, especially in Malaysia, that if the lowland dipterocarp forests had not been converted for agricultural development, SFM would have been achieved. This is a doubtful claim, considering the problems with overcutting and heavy logging damage, the uncertainty associated with the regeneration of preferred species in logged forests, and the low financial competitiveness of SFM compared with agriculture (when services provided by the forest are not adequately remunerated). Hence, if SFM is ever to be realized there is an urgent need to demonstrate to decision-makers that the ecological and protective values of the forests far exceed those of timber production alone.

An even more contentious issue for SFM is meeting the needs of local communities. Contrary to popular belief, this issue was recognized early and given high priority in India (Stebbing, 1926). Later, however, emphasis was placed on reserving and conserving forests, without due concern for the needs of local communities. These imbalances are now being redressed, slowly, through policy and regulatory measures and by decentralization and devolution processes to return tenurial rights to the people – admittedly only after much of the timber wealth has been exploited by those with or close to political power. But much more still needs to be done in this regard. There is also a need to assist local rights-holders to implement SFM.

Technically, there is little reason why SFM that includes commercial-scale timber harvesting cannot be achieved in closed moist natural tropical forests by improving silvicultural and harvesting practices to reduce logging damage and ensure that harvesting and regrowth are in balance (Putz, 1994). But without political will and in the face of sustained pressure for quick profits, purely technical solutions are impotent. Historically, the profits derived from commercial timber extraction have favoured a relatively narrow segment of society, and approaches that meet the needs of multiple stakeholders, and distribute benefits more equitably, have a better chance of ensuring forest permanence. Silvicultural approaches certainly need to evolve further, but until the holders of land rights and land-use rights are convinced that the best use of the land is the management and maintenance of the forest growing on it, silvicultural solutions are unlikely to achieve their expected goals. ◆

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Traditional knowledge and SFM: experience from Malaysia

F. Tongkul, C. Lasimbang, A. Lasimbang and P. Chin Jr

PACOS TRUST

Healthy forests provide local communities in Sabah with wild vegetables and herbs

Forest knowledge held by indigenous communities has a vital role to play in forest management.

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Traditional management practices have contributed enormously to the world's natural and cultural heritage by creating and maintaining landscapes that sustain the production of multiple goods and services and therefore livelihoods. Traditional forest knowledge is based on long historical experience and deep insight into the dynamics of forest ecosystems and the behaviour and characteristics of a wide range of animal and plant species. Most of the world's primary forests and biodiversity hotspots are in regions with high diversities of indigenous cultures and their associated traditional knowledge and wisdom.

Today, owners of traditional forest knowledge face significant challenges, especially encroachment onto their lands and expropriation of those lands, leading to forest degradation and the erosion of traditional cultures, values and lifestyles. If disconnected from their natural environments, indigenous communities inevitably lose their traditional knowledge and usually end up among the world's poorest people.

There are some hopeful signs, however. There is growing awareness among forest scientists, for example, that local

communities who possess traditional forest knowledge can play important roles in co-managing forestry sustainably (e.g. Fortmann and Ballard, 2011; Ramakrishnan, 2007; Pei, Zhang and Huai, 2009; Herrmann, 2006). Collaboration between decision-makers, forest managers and local communities is increasingly recognized as a key to sustainable forestry (Parrotta and Trosper, 2012). And there are many initiatives by indigenous peoples' organizations, non-governmental organizations (NGOs), national governments, intergovernmental organizations and others related to safeguarding traditional knowledge (UNCCD, 2005).

In Malaysia, collaboration between international agencies, government, NGOs and communities to promote sustainable forestry has been on the rise for 20 years (UNDP, 2008; Escobin, Gonslaves and Queblatin, 2008; SFD, 2012). This article describes efforts to integrate traditional forest knowledge with sustainable forest management (SFM), the strengths and weaknesses of such integration, and obstacles to it in Sabah, a state in Malaysian Borneo.

TRADITIONAL FOREST KNOWLEDGE IN SABAH

The indigenous peoples of Sabah

About 62 percent of Sabah's 3.2 million people are indigenous, comprising several groups such as the Kadazandusun, Bajau, Murut and Malay (Department of Statistics Malaysia, 2010). The Dusunic, Murutic and Paitanic ethnic groups (King and King, 1984) are mostly found in rural areas, and a large percentage of the total population lives in forested areas. These rural communities depend on three major resources – land, forest and water – to sustain their traditional livelihoods. They need enough land to farm because in most cases agriculture is a major source of their daily food. Where rural communities and people have legal ownership of land, permanent crops like fruit trees and rubber are planted on a small scale. The forest is important as a land bank and as a source of food, medicine and materials to make houses, handicrafts, utensils and farming equipment. Although there is no specific regulation regarding forest use, it is understood by local people that forests near a given village belong to the community and are usually claimed under native customary rights. Streams and rivers are the main source of water for household needs. Clean rivers are required to maintain fish populations, an important source of protein.

A typical rural village surrounded by natural forest located within a designated class II commercial forest reserve, Sabah

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Traditional forest knowledge

Traditional knowledge related to forest management is yet to be documented systematically in Sabah. To the extent to which it is known, traditional knowledge can be classified broadly into three categories: landscape diversity; biodiversity and resource use; and traditional governance.

The long association of indigenous communities with their physical surroundings for gathering, hunting and farming makes them highly knowledgeable about local topography, landscapes and micro-ecosystems. For example, indigenous communities have intimate knowledge of their water catchments, including the location of springs, which in Sabah are sacred places for indigenous communities and are associated with high plant diversity. Indigenous communities have knowledge of trails and the migratory paths of certain animals, and they know the locations of caves and waterfalls. Based on this knowledge, indigenous communities usually assign the use of their ancestral areas by function, such as burial grounds, community-owned sacred forests (primary forest), farms (secondary forest), and hunting grounds.

The dependence of indigenous communities on forests to sustain their traditional livelihoods makes them very knowledgeable about the types and richness of plants and animals present in their areas. There is knowledge of the trees most associated with certain animals, birds, bats and insects. Sabah's indigenous communities have detailed knowledge of specific types of trees, vines and other plants suited to their daily needs.

Indigenous communities have their own mechanisms for the orderly use and management of their forests based on their *adat*, or customs (Tongkul, 2002). *Adat* operates on the simple principle that everything is interconnected – physically and spiritually. All things, living or dead, have spirits and are somehow related to and need each other. This relationship needs to be kept in balance to create a harmonious environment for all beings. The natural resource is seen as God-given and should be taken care of by all. Thus, it is generally the accepted norm that users will take only what is needed when collecting from the forest. Every user is expected to look after common resources, based on a concept called *gompi–guno* ("use and care"). Should an area become overused it is the responsibility of everyone in the community to leave it to regenerate. Traditional agricultural practices, often seen to be in conflict with forest conservation, are in fact highly dependent on the availability of forestland for their continuation. To ensure that forests are kept healthy and productive, unnecessary clearing and tree-cutting is prohibited. The opening up of farmland is usually done on a small scale based on a family's capacity and need, and is restricted to secondary forest. When the fertility of the land is reduced by farming, a fallow period, usually five to seven years, is observed to give the land a rest and to restore its fertility.

COMMUNITY FORESTRY IN SABAH

Sabah's forests

Sabah is richly endowed with forests. Of the total land area of 7.4 million hectares (ha), about 60 percent, or 4.5 million ha, is under forest cover. Of the total forest area:

- 3.6 million ha (49 percent) is allocated as forest reserves ("permanent forest estate") and managed by the Sabah Forestry Department (SFD);
- 0.25 million ha is allocated as national parks and managed by Sabah Parks;
- 0.03 million ha is allocated as water catchment and managed by the Drainage and Irrigation Department;
- the remainder (0.9 million ha) is designated as state land, which ultimately will be deforested, mainly for agriculture.

Forest reserves gazetted under the Sabah Forest Enactment, 1968, are classified into seven classes according to function. A large part (about 2.7 million ha) of the forest reserve estate is classified as class II commercial forest reserves. In the past, these reserves produced very large quantities of timber – they contributed more than 50 percent of the state's revenue between the 1970s and the early 1990s. Nearly all class II commercial forest reserves are now logged-over or secondary forests, and extraction in the past was largely unsustainable. Timber production in Sabah plummeted from a high of about 12 million m^3 in the early 1980s to about 2.2 million m^3 in 2011, in which year it contributed only about 5 percent to state revenue (SFD, 2012). It is expected that timber production will decline further in the future. Despite this, forestry is still considered an important sector, and the state government has committed to bringing all forest reserves under SFM.

A model SFM area, the Deramakot Forest Reserve, was developed during the Malaysian–German Sustainable Forest Management Project that operated from 1989 to 2000. The model recognizes the multiple functions and uses of forests and addresses the future productivity of the forest and the environmental impacts and economics of the forest operation. A comprehensive planning procedure, implementation guidelines and monitoring at various management levels were introduced to resolve the many economic, social, environmental and technical challenges of SFM. Based on the model, in 1997 the Deramakot Forest Reserve became the world's first tropical rainforest to be certified under the Forest Steward Council (Malaysian Timber Council, 2008).

In September 1997, the state government adopted the SFM concept, as embodied in the Deramakot Forest Reserve model, for state-wide application to some 2 million ha of forest by signing long-term SFM licence agreements (SFMLAs) with ten private companies. SFMLAs are vehicles designed to expedite SFM adaptation and implementation. As of 2011, a total of 27 such licence agreements had been signed, under which the companies, in cooperation with the SFD, are required to manage the production forest reserves within their forest management units in accordance with SFM. Apart from the

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Indigenous women tend sweet potatoes grown between young rubber trees planted as part of a Sabah Forest Department agroforestry project

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Young villagers pose in a community nursery to supply seedlings of indigenous tree species to enrich community forests in the Ulu Moyog area, Penampang District. The development of the nursery was supported by the EC–UNDP Small Grants Programme for Operations to Promote Tropical Forests

Deramakot Forest Reserve, several forest reserves covering a total of 864 000 ha of forest are now subject to some form of certification (SFD, 2012). Since 2011, the SFD has been taking the lead in developing a roadmap for the uptake of REDD+ (reduced emissions from deforestation and forest degradation in developing countries) in the state (World Wide Fund for Nature, 2011).

In recent years there have been substantial efforts to promote community forestry in Sabah, both by the SFD and through an external small-grants programme. These efforts are described below.

SFD community forestry projects

One of the challenges faced by the SFD in implementing SFM is the issue of ensuring the rights of local indigenous communities living within and adjacent to forest reserves. The SFD estimates that there are about 20 000 people living within forest reserves statewide, and an unknown number of people live in the fringes of forest reserves. Most of these people are extremely poor, with little or no access to basic facilities and amenities and with a heavy dependence on forests for survival.

The SFD has undertaken various measures to improve the living conditions and livelihoods of communities and to help safeguard forest reserves from further degradation. One such measure is the introduction of community forestry projects in several key areas (SFD, 2012), beginning with the Kelawat Forest Reserve joint forest management community project in 1992. As of 2012, four projects had been implemented in the Kelawat, Lingkabau, Mangkawagu and Bengkoka forest reserves, with variable success (Table 1). Community forestry projects involve the conservation of primary forest, the restoration of degraded forest, the development of agroforestry and the provision of housing and basic amenities to affected communities.

EC–UNDP community-based forestry projects

In 2004–2007, several community forestry projects were implemented throughout Malaysia with funding from the European Commission (EC)–United Nations Development Programme (UNDP) Small Grants Programme for Operations to Promote Tropical Forests, with a long-term development objective of improving the livelihoods of poor, forest-dependent communities by strengthening the links between economic enterprise and sustainable forest use and management. Some of the projects demonstrated good practices that brought about positive change and reinforced the commitment of communities to look after their forests (Kadazandusun Language Foundation, 2006). In Sabah, seven projects were initiated and implemented by indigenous communities themselves, some in collaboration with NGOs, community organizations and the SFD (Table 2). They involved a range

TABLE 1. Community forestry under the SFD in Sabah

Project; initiated; community	Background	Joint activities	Achievement
Kelawat Forest Reserve Joint Forest Management project; initiated in 1992 between the SFD and local communities; Kampong Ponopuan, Kota Belud District	• 70% of forest areas under the Kelawat Forest Reserve are degraded and devoid of forest cover • The forest reserve has been opened for farming and rubber cultivation by local communities	• Biodiversity protection of remaining natural forest • Replanting of indigenous tree species and rubber and fruit trees in degraded forest • Alternative socio-economic activities	• Biodiversity of undisturbed natural forest protected • Biodiversity in degraded areas restored (20 000 trees planted) • Basic subsistence needs addressed
Gana Resettlement and Integrated Development project; initiated in 1998; Kampong Gana, Kota Marudu District	• Forests in the Lingkabau Forest Reserve are degraded • Ten villages are scattered within and adjacent to the forest reserve • The Sabah government wants a development model that meets the needs of the communities and at the same time protects and conserves the forest	• Complete settlement of all villages in one area • Alternative socio-economic activities for the resettled communities • Agroforestry programme • Forest restoration of water catchment	• Basic infrastructure provided • Critical access road to settlement in progress • Basic subsistence needs addressed • Training in “modern” agriculture provided • Rubber plantation implemented
Mangkuwagu Forest Reserve project; initiated in 2006; Alatang, Mangkawagu, Saguan, Tampasak Darat and Tampasak Laut kampongs, Tongod District	• The forest is degraded • Several villages are located within the forest reserve	• Capacity-building of communities • Development of economic alternatives • Community forestry • Establishment of forest management and certification committee • Review of current legal framework for forest management	• Community forest compartments set aside for local communities • Physical development (road access) provided • Agroforestry project (rubber plantation) implemented in community compartments
Bengkoka Forest Reserve project; initiated in 2006; Sorupil, Ungkup, Gumpa and Bongkol kampongs, Pitas District	• Forest is degraded • Several villages are located adjacent to the forest reserve	• Forest restoration programme (tree-planting) • Agroforestry programme	• Physical development (road access) provided • Agroforestry project (rubber plantation) implemented in community compartments • Forest restoration of forest reserve implemented (40 000 trees planted)

TABLE 2. Community forestry activities under the EC–UNDP Small Grants Programme for Operations to Promote Tropical Forests, Sabah, 2004–2007

Project; community; organization (organization type)	Background	Activities	Achievement
Community initiative on natural resource management and poverty eradication; Ulu Moyog area, Penampang; PACOS Trust (NGO)	• Forest areas in water catchments, national parks and forest reserves and on state land were threatened by farming • There was no existing formal cooperation between several communities • Traditional forest knowledge was not promoted	• Reviving traditional knowledge on forest management using the *gompi–guno* concept • The establishment of a network among ten villages on resource conservation • Capacity-building • The development of new economic activities	• Forest in water catchment enriched • Several medicinal gardens established in community forests • Indigenous tree nursery established
Replanting, conservation and maintenance of communal forest and water catchment areas; Kampong Kalampon, Keningau; *Pertubuhan Rakyat Kampong Kalampon* (community organization)	• Forest area in water catchment was degraded	• Enrichment of water catchment area • Revival of interest in a small sacred hill within the catchment	• Forest enriched • Heightened interest in looking after the hill
Creating alternative economic activities to conserve and protect the community's forest resources and water catchment zones; Kampong Tiong, Tamparuli; *Pertubuhan PUSAKAG* (community organization)	• Forest area on state land was threatened by farming because it was located on an individual title	• Work with the owner to conserve forest in the water catchment area by planting fruit trees • Development of an agreement between the owner and community management	• Forest enriched • Agreement for long-term community use signed
Conservation and management of natural resources at Bukit Gumantong communal water catchment; Kampong Tinanggol, Kudat; *Pertubuhan MONUNGKUS* (community organization)	• Forest areas in water catchment was degraded by forest fire and invasion by *Acacia mangium*, an introduced tree species that seemed to have a negative effect on water supply • There was a decreased supply of materials for handicraft-making	• Weeding of *Acacia mangium* and replanting in catchment areas • Conserving remaining forest • Training in handicraft-making to younger generation • Capacity-building	• Water catchment rehabilitated • Medicinal garden established
Knowledge-based integrated management of forests for the benefit of the local community; Kampong Bundu, Keningau; *Pertubuhan MAMAKAT* (community organization)	• Forest area in water catchment was degraded due to illegal logging	• Planting of trees in water catchment areas • Repair of gravity pipes • Capacity-building • Income generation by planting ginger	• Forest enriched • Water source secured • Community organization strengthened • New source of income established
Management and conservation of water catchment area; Kampong Gana, Kota Marudu; *Kelab Belia Kampung Gana* (NGO)	• Communities resettled by the SFD in Gana Resettlement and Integrated Development Project • The forest area in forest reserve was degraded • There was limited economic activity	• Mapping of catchment area • Planting of indigenous trees • Capacity-building • Creation of food-processing house	• Forest enriched • Youth organization strengthened • New industry established
Maintenance and management of natural resources in water catchment; Kampong Liu Tamu, Pitas; *Pertubuhan KOMOKITUKOD* (community organization)	• Forest in water catchment was invaded by *Acacia mangium*	• Control of *Acacia mangium* • Replanting in catchment areas • Conserving remaining forest • Capacity-building	• Forest rehabilitated • Fruit trees planted • Medicinal garden established

of activities, such as the conservation of communal forests; the replanting of indigenous tree species in degraded forest in water catchments, national parks and forest reserves and on state land to secure community water supplies; the establishment of medicinal gardens; and the setting up of new economic activities.

CHALLENGES IN INTEGRATING TRADITIONAL KNOWLEDGE IN THE SFM CONCEPT IN SABAH

Observation on community forestry programme

The on-going community forestry projects by the SFD and community-based forestry projects under the EC–UNDP Small Grants Programme for Operations to Promote Tropical Forests have made some progress in integrating traditional knowledge in forest management in Sabah. The SFD has shown a willingness to engage local communities in addressing the long-standing problems of deforestation and land degradation in its forest reserves. The

linking of socio-economic incentives and forest development has been instrumental in eliciting community participation. The success of most of the projects has demonstrated that local communities are equally committed to protecting their community forest if given the opportunity to participate meaningfully.

While the partnership between the SFD, NGOs and community organizations is commendable, however, the incorporation of traditional knowledge in forest management is yet to be fully realized. The community forestry projects under the SFD in production forests are mostly geared towards providing basic infrastructure and introducing agroforestry practices (rubber planting), with minimal inputs of traditional knowledge from the local communities. Communities participate little in the actual management of natural forest areas; their task is mainly to assist the SFD in the reforestation (seedling preparation and planting) of degraded natural forest. Except for the Kelawat Forest Reserve Joint Forest Management project, no proper joint management of natural forest has been implemented in which there is a clear mechanism by which local communities and the SFD will meaningfully co-manage the forest and share the benefits.

None of the private companies under SFMLAs has shown significant progress in the co-management of community forest with local communities. Similarly, about half the community-based forestry projects under the EC–UNDP Small Grants Programme for Operations to Promote Tropical Forests are geared towards forest enrichment in water catchment areas and building capacity among local communities to meet their immediate economic needs. Except for the Kampong Tiong project, where a long-term agreement has been established between the community and the individual owner of the land to conserve the forest area, there has been little effort to establish proper joint forest management between local communities and relevant government bodies such as the SFD, Sabah Parks and the Drainage and Irrigation Department.

Outstanding issues related to SFM

The implementation of SFM in Sabah is a work in progress, and there are still many hurdles to overcome (SFD, 2012). One of the key issues hampering the implementation of SFM is the determination of local community ownership of land inside forest reserves – the Sabah Forest Enactment, 1968, does not allow for native title ownership within forest reserves. This issue came up strongly during the recent National Land Inquiry by the Human Rights Commission of Malaysia (Vanar, 2012). Forest reserve boundaries were not drawn and marked on the ground until very recently – in most cases only after 2000. Therefore, many affected communities were unaware that their lands were within a forest reserve until the arrival

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Community members work to rehabilitate a highly degraded forest invaded by* Acacia mangium *with indigenous tree species in Kampong Liu Tamu, Pitas District

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Project staff document a community herbal garden established during a project in the Ulu Moyog area, Penampang District, with the support of the EC–UNDP Small Grants Programme for Operations to Promote Tropical Forests

of logging companies or the posting of notices by authorities warning against trespassing. Since the establishment of many forest reserves did not involve ground surveys that could have ensured that communities and their native customary rights territories were excluded from the reserves, the SFD issued a circular in 1998 allowing communities living within such reserves to stay there and to continue their farming activities. However, they are not permitted to expand their farms within the forest reserves.

Land is critical to the survival of indigenous communities. For them, it is insufficient to be allowed to farm or cultivate rubber in assigned community forestry areas. They want formal ownership of the land that they consider rightly belongs to them under native customary rights. As custodian of the forest reserves, the SFD does not entertain such claims. Affected local communities therefore view the SFD with suspicion, despite the SFD's efforts to encourage them to participate in community forestry projects such as those in the Mangkawagu and Bengkoka forest reserves. To the communities, such participation would be akin to relinquishing their ancestral land to the SFD in exchange for minimal benefits from projects that do not guarantee secure tenure. Establishing genuine partnerships between the SFD and local communities in this kind of situation, therefore, is challenging. Despite the requirement under FSC certification and more recently REDD+ – both of which the SFD is actively promoting – to recognize the rights of local communities to their ancestral lands and to fully consult them prior to development, the situation on the ground has not improved.

CONCLUSION

The Sabah experience shows that traditional knowledge on the use and management of forests still has a vital role in forest management. Local communities who possess this knowledge are willing to participate in managing community forests sustainably, if given the opportunity. Collaboration between government departments, NGOs and local communities is getting stronger, but the integration of traditional knowledge in SFM still has a long way to go. For traditional forest-related knowledge to be fully incorporated in SFM, the communities, who possess this

knowledge, must be fully acknowledged, properly consulted and genuinely engaged. Local community requirements to maintain their traditional livelihoods, and their ownership of the land, must be respected. More capacity-building for communities and research support on traditional knowledge is needed. There is also a need to further explore benefit-sharing and other joint-management arrangements.

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The sustainability of traditional community forest management systems: lessons from India

J.R. Matta, R. Ghate and H. Nagendra

Traditional forest institutions work, but their restitution requires fundamental reform through decentralization.

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Since the dawn of the nineteenth century, the ecological and cultural landscapes of forest-fringe societies have transformed dramatically. Growing populations, top-down policies and market forces have led to the rapid depletion of natural wealth and the abandonment of many traditional systems. In rural India, communities are threatened by, among other things, abject poverty, a lack of economic opportunities, and the looming consequences of climate change. Changing global market dynamics and associated development patterns have also brought about changes in community values, attitudes and livelihoods that affect the need, ability and willingness of local people to work collectively in forests.

Reporting on recent studies in India, this article examines traditional systems for managing local natural renewable resources and the contributions they have made to the concept of sustainable

Forest-dependent women participate in a survey. The effective engagement of women, including recognition of their needs, is critical to the sustainability of any community-based forest management system

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The field setting for a behavioural experiment described in case study 1

resource management. The article explores the question of whether community values remain strong enough to catalyse sustainable forest management, and examines factors that could enable or constrain village societies in their forestry efforts today.

SUSTAINABILITY AND TRADITIONAL NATURAL RENEWABLE RESOURCE MANAGEMENT IN INDIA

Long before the modern world coined the words sustainability and sustainable resource management, these concepts were already deeply ingrained in traditional customs and cultural practices in India. Ancient scriptures emphasized the importance of ecological preservation and moderation in the use of natural resources. Many traditions of Indian worship consider that all nature, be it rivers, mountains, lakes, forests, stars or sky, is pervaded by a divine presence, and even today there is great reverence and respect for nature.

Over the years, social customs and religious beliefs and rituals influenced the attitude of communities towards forests and resulted in the evolution of distinct systems of management. Although not without instances of conflict, these systems were widely adhered to, within and outside communities, and were monitored closely locally. Some of the common traits of traditional systems are: a holistic view of ecosystems; a deep attachment to culture and traditions (e.g. cultural festivals reinforcing belief in the preservation of nature); resource ownership attributed to communities; and restricting the use of natural resources to the meeting of basic needs.

In contemporary India, the term "indigenous people" is synonymous with the word "tribal", indicating these communities to be *vanvasi* (forest dwellers) or *adivasi* (original inhabitants). Etymologically and spatially, the lives and livelihoods of these tribal communities are linked intrinsically with forests (Mitra and Gupta, 2009). Their lifestyles are usually defined by the absence of exploitive classes and organized state structures; the complex ways and means by which they relate to each other and cooperate within and between kinship bonds; the all-pervasiveness of religion; frequent cooperation among members towards common goals; a low level of technology; the segmented character of the socio-economic unit[1]; distinct taboos, customs and moral codes; and common territories, descent, language and culture (Pathy, as cited in Xaxa, 1999). Although there are many tribes in India and a wide range of linguistic and cultural differences among them, their attitudes to forest protection are commonly determined by religious dictates (e.g. the dos and don'ts in sacred groves), belief systems and social norms (Gadgil and Guha, 1992). Tribal traditions generally exhibit pro-social behaviour towards forests (Gurven and Winking, 2008). The following case studies illustrate that traditional systems remain strong in many communities in India.

CASE STUDY 1: COOPERATION FOR SUSTAINABLE HARVESTING

Two studies were conducted between January 2009 and April 2011 in eight tribal villages in the state of Maharashtra that differed in their locations, dialects, state of adjoining forests, and the capacity of local forest management institutions.[2] The studies were designed to capture attitudinal aspects underpinning individual behaviour expressed through privately taken decisions on forest use. Such decisions related to the harvesting of trees; the non-wood forest products collected; the level of dependence on forests; the establishment of forest plantations in degraded forest; and responses to increases in payments from forest-related activities.

The studies involved experiments using games concerning common-pool resources designed to be relevant to participants, so that participants' behaviour in the experiments correlated with their behaviour in real-world situations. At the start of each game, 100 small paper cut-outs in the shape of trees were stuck on a board placed prominently in a room. The five players in each game were informed that these trees represented the forest about

[1] Indigenous communities in India mostly participate in a low-skilled agricultural sector that generates low income and offers little opportunity to upskill, which tends to be self-perpetuating. The occupational distribution is also often fixed (segmented), increasing the difficulty of transitioning to higher-skilled occupations.

[2] The methodologies and results of these studies are published in full in Ghate, Ghate and Ostrom (2011) and Ghate *et al*. (2012).

which they were to make decisions. They were also told that they would individually "harvest" these trees, and that there would be a group discussion prior to the harvesting "operation" to set the harvesting rules. A number of paper trees (determined to be the total allowed maximum harvest size for that round in the game) were placed next to an empty box on a table in another room. Players entered this room in turn and dropped into the box the number of trees they wished to harvest in that round. A player could refrain from dropping anything into the box to indicate that he did not wish to harvest at all in that round. The organizer recorded the number of trees harvested by each participant, removed the trees from the box and placed them back on the table. Thus, the next player in the same round had the same number of trees available for harvesting and did not know the number of trees harvested by the previous player. Each player kept track of the number of trees he had harvested in all rounds. At the end of each round, the total number of trees harvested by the five players was disclosed to the group.

The results confirmed the prevalence of systems of mutual trust and cooperation in the communities. Participants discussed harvesting decisions, mainly in the initial rounds. Once decisions were taken, they were followed in the remaining rounds, with few infractions – even though infractions would have increased individual earnings – and there was no need for explicit verbal sanctions. There were four instances in which *fewer* than the allowed number of trees were harvested, one of which is described below.

The prisoner's dilemma

The prisoner's dilemma is the term given to an element of game theory related to cooperation between two (or more) parties. The idea is that each player in a given game (or life situation) gains when both cooperate, but if only one cooperates, the other, who defects, will gain more. If both defect, both lose (or gain very little), but not as much as the "cheated" party whose cooperation is not returned (Heylighen, 1995). Extending this to a natural resource, one might expect that individuals will take more than their agreed share – trees, in this instance – because of the risk that others will do so, hence depriving individuals who stuck to the agreement. In this study, however, the president of the forest management committee harvested fewer than his permitted individual share of trees (the number having been agreed in advance, in group discussions). When asked why this was the case, he responded that he did so in case other members harvested more than their permitted share – that is, to protect the forest from the possibility of degradation. This precaution on the part of the president, although admirable, turned out to be unnecessary, because none of the other participants harvested more than their agreed share.

Arguably, this behaviour contradicts the theory of the prisoner's dilemma. The absence of infractions and the need for the exchange of only a few words – and even then only in initial rounds of the game – indicate the prevalence of mutual trust. In one series of four experiments, the payoffs were doubled in one of the experiments, yet it made no difference to harvesting decisions (Ghate, Ghate and Ostrom, 2013).

An important observation of the Maharashtra studies is that "harvesting" in the communities was conservative in that it did not over-use the resources. In some sense the simulated harvesting could be termed suboptimal – that is, the communities could have harvested more trees sustainably without adversely affecting the sustainability of the resource. Ostrom (1998) called this "better than rational" behaviour. In many laboratory experiments featuring the prisoner's dilemma, it has been observed that if players are told the number of rounds to be played there will be overkill in the final rounds, with heavy and unsustainable rates of harvesting. Yet in the Maharashtra studies the behaviour – at or below the maximum allowable harvesting – was consistent throughout the various rounds of the game. The harvesting rules determined in advance by the group were followed, with no infractions.

The players in these games understood that overharvesting would eventually deplete the resource and preferred long-term benefits over quick gains, even though this meant sacrifices on their part. The studies also revealed the communities' extensive knowledge of growth potential and their willingness to follow appropriate management practices. They indicated that, given a proper platform for participatory decision-making, indigenous communities are likely to adopt norms of conservation, often also addressing issues of equity and making conscious efforts to promote moderate harvesting. The take-home message here is that even after many decades of a centralized forest management regime, the essence of cooperative, non-exploitative behaviour still exists in the indigenous communities that can be relied on and encouraged through decentralization policies.

CASE STUDY 2: COMMITMENT TO CONSERVATION IN THE FACE OF EXTREME CHALLENGES

Located in the central Indian dry forest belt in an area rich in biodiversity, the Tadoba Andhari Tiger Reserve is one of India's best-known tiger conservation areas. Like many national parks and wildlife sanctuaries in India, however, it is surrounded by communities of extremely poor people – mainly ethnic indigenous tribes, in this case largely from the Gond community – who are highly dependent on forests (Nagendra, Pareeth and Ghate, 2006). With the formation and expansion of the tiger reserve, many tribes faced severe restrictions on their traditional rights to access forest products and conduct livelihood activities inside the area (Ghate, 2003). Their settlements in the forest close to the tiger reserve has become both a blessing and a curse: while they continue to meet many of their needs from forests, such as timber, fuelwood, medicine, livestock grazing, honey and

CT'S NAIR

A wild tiger in the Bandhavgarh Tiger Reserve, India. Human–wildlife conflict is a growing natural resource management issue in India

other non-wood forest products, they are also subject to crop and livestock losses from wildlife, as well as to direct attack by tigers. The communities are rarely compensated for such losses or attacks and, in cases where they are, it is usually insufficient. The communities also lack access to basic facilities due to their remote locations and the restrictions placed on their traditional activities in the protected area.

Despite these challenges, a recent study (Nagendra, Rocchini and Ghate, 2010) in six villages in the Tadoba Andhari Tiger Reserve indicated that a majority of people identified forest conservation as an important goal and were keen to be involved in forest protection and monitoring, reinforcing the communities' historical and symbiotic association with forests. For them, forests are an important common-pool resource; social norms for their sustainable management evolve naturally, given an opportunity. These norms strongly influence resource-use patterns and discourage overexploitation for short-term benefit, while also helping to minimize the negative impacts of wildlife conservation on local livelihoods.

CONTEMPORARY CHALLENGES AND THE POTENTIAL FOR REVIVAL

In highly productive forest areas with small human populations, the needs and interests of local stakeholders can often be met with few compromises on forest quality: past studies have indicated positive associations between local collective action and good forest condition (Lise, 2000). In such situations, the introduction of incentives for local participation, such as shares of the proceeds from wood and non-wood forest products and ecotourism, could be reasonably simple and sustainable, although it may face typical collective-action challenges (Vira, 1999).[3]

The involvement of local people and sustaining their interest in resource management is more difficult when the benefits are not high, immediate or widely distributed (Kerr, 2002). Given that most forests in India available for community management are degraded, they may often be insufficiently productive to inspire enthusiasm for management among local people. In general, users living at a subsistence level will have an incentive to conserve their resource base because they

[3] "Collective action" describes a situation in which multiple individuals would all benefit from a certain action, but the action has an associated cost that makes it implausible that any one individual can or will undertake the action alone. In addition to the transaction costs, challenges include, for example, "free riding" and ensuring fairness and justice.

TAMIL NADU FOREST DEPARTMENT

Women weave baskets in a women's self-help group in Tamil Nadu. Establishing women's self-help groups and promoting skills in the processing of, and value-adding to, forest products are key components of JFM in many Indian states

have limited alternative income options, but if the resource is degraded, such users may be unable to restore it to a level where it will provide good, sustainable livelihood opportunities. In such circumstances, there are good grounds for external interventions that assist poor users to overcome barriers to local investment in sustainable management.

Continued reform is needed

The Indian Government's approach to forest management began to evolve towards greater participation in the 1980s with programmes such as joint forest management (JFM). The Forest Rights Act, 2006, moved the process a step further, promising a significant transfer of rights to tribal groups despite some apprehensions. Concerns about the Act were expressed particularly by conservation groups, some of which took the issue to the courts because they were worried by the possible dilution of biodiversity protection and conservation efforts.

In some cases, practices such as JFM have helped restore local environments (Sreedharan and Matta, 2010). In many others, however, such practices have been unable to ensure sustainability due to a lack of involvement of local communities in decision-making; a lack of tenure and access rights, particularly given the long-term nature of forestry; and a heavy dependence on external agencies (Matta, 2006). Overall, an explicit linkage was lacking between the devolution of local responsibilities for forest conservation and the right to devise locally suitable, adaptive and flexible rules for forest management at a community level (Ostrom, 2005; Ostrom and Nagendra, 2006). Such a linkage requires the strong involvement of local people in planning and management processes, which, in turn, requires appropriate institutional arrangements and support.

Early investment is needed

It is in this context that the role of incentives and secure resource access rights are particularly important if local management traditions are to be revived and placed on a strong footing. Some indigenous institutions such as sacred forests function effectively to safeguard biodiversity through traditional rules, without any external inputs in terms of money or forest interventions (e.g. Nagendra and Gokhale, 2008). In many larger, contested or especially degraded forest patches, however, monetary investments may be required in initial years, not only to increase forest productivity but also to strengthen local institutional capacities (Ghate, Mehra and Nagendra, 2009).

People value and use forests for many purposes other than social and economic; the psychological benefits – such as an increased sense of satisfaction and reduced stress – are often also important (Sundar, 2000). Thus, incentives must go beyond the financial to include wider social issues such as tenure, community development, social recognition and institution-building. Effective and sustainable local natural resource management requires the presence of appropriate mechanisms to generate financial returns, legal empowerment to enforce institutional obligations, and accountability for allocated responsibilities. The effective engagement of women, including recognition of their needs and their participation in decision-making, is also critical. The ultimate objective should be to progress from the current emphasis on the participation of local communities in government programmes to the promotion of decentralized governance where local people have greater power and ability to make informed decisions in managing their resources and institutions (Matta and Kerr, 2007).

MOVING FORWARD

Traditional management systems in India worked well for as long as communities held together and were not disrupted by external forces. Restoring such systems to meet wider needs for forest goods and services, however, requires the genuine and committed transfer of power, resources and responsibility from central authorities to lower levels of governance (Nagendra and Ostrom, 2012).

Effective and sustainable local resource management also entails active community participation, appropriate legal measures to enforce institutional obligations by communities, mechanisms to generate needed financial resources, and accountability to deliver the responsibilities entrusted (Matta and Kerr, 2007). Thus, rather than providing project-based external assistance, decentralized governance should be the main approach to restoring local forms of natural resource management. Those to whom responsibilities are devolved should be allowed to set objectives themselves, rather than being expected to meet the objectives set by others.

There is also a need for various ministries and departments engaged in tribal areas to statutorily recognize local forest management institutions. In the absence of such affirmative action at the top policy level, it is unrealistic to expect local villagers to bring about fundamental changes in the way forests are governed or to ensure their sustainable management. More importantly, maintaining the *status quo* could lead to further environmental degradation and could further entrench rural poverty and staggering social and economic inequities. ◆

R. GHATE

Villagers stand near a sacred grove in Maharashtra. Sacred groves are maintained by local communities and are generally associated with a presiding deity; they often act as reservoirs of rare flora and fauna, and hunting and logging are strictly prohibited in them

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M.SURESH

Traditional Indian toys, handmade by Indian artisans

Wooden toys in India

P.K. Aggarwal, R.V. Rao and S.C. Joshi

The toy-making industry is part of the country's rich cultural heritage, but action is needed if it is to prosper.

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People have been making wooden toys on the Indian subcontinent since the civilizations of Mohenjodaro and Harappa, up to 5 000 years ago. Today, wooden toys are manufactured by traditional artisans throughout India and especially in the north, northeast, centre and south, depending on the availability of raw materials. A wide range of timbers is used, such as the lightweight species *Givotia rottleriformis* in Karnataka and *Wrightia tinctoria* in Andhra Pradesh, and the well-known sandalwood (*Santalum album*) and rosewood (*Dalbergia sissoo*). But the industry is under threat, including from a lack of raw materials. This article discusses some of the issues facing Indian traditional wooden toy-making and the actions required to ensure its viability.

INDIA'S TOYMAKERS

Traditional wooden-toy making constitutes an important part of India's cultural heritage. Traditional toys depict, in different ways, the country's rich history, mythologies, legends, folklore and plant and animal life, and they have always been popular in both urban and rural markets. Thus, Indian wooden toys have a tradition of linking play and amusement with religion, history, art and education.

Traditional wooden-toy making is conducted mainly at the cottage-industry scale, and most artisans are "unorganized", meaning that they operate independently (Kumar *et al.*, 1996a). Traditionally, artisans use very simple hand tools, but some are turning to power tools such as lathes, jigsaws, circular saws, fretsaws and spray-painting equipment. The wood favoured by artisans is soft to moderately hard, has a fine texture and is easy to carve into desired shapes, although ultimately the choice of wood depends on availability. Traditional toymakers use lac, an insect-derived substance that is melted and solidified into sticks. The required size and shape of wood is cut, seasoned, attached to a lathe operated either manually or by motor, and turned in order to smooth it. Chisels are

used to shape the revolving piece of wood, and flaws are sandpapered. The surface is lacquered by rubbing lac sticks into the revolving wood.

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MAJOR CENTRES OF TOYMAKING

The main centres of wooden-toy making are Meerut, Moradabad, Sharanpur, Nagina and Srinagar in northern India; Assam, Tripura, Nagaland, West Bengal and Rajasthan in the northeast; Bhopal and Jabalpur in central India; and various centres in southern India (see Table 1, which also shows the main timber species used, by state and population centre, in southern India). Some areas have particular specialties, such as idols in sets of various shapes, animal figures, and models of musical instruments.

CHALLENGES

The problem of raw-material supply

The materials used in traditional wooden-toy making fall into two categories: wood, the basic raw material from which toys are made; and subsidiary materials such as aluminum, zinc, waste coir and cotton, mogali (kewada) leaves from *Pandanus fascicularis*, sawdust, ochre (derived from clay containing mineral oxides), orpiment (an arsenic sulphide mineral compound), chalk powder, gums and pastes, gurjan oils (from *Dipterocarpus turbinatus*), and other natural colours and paints.

India has a rich diversity of tree species, including about 1 600 species with timber of commercial value. The major species used traditionally in the toymaking sector are *Adina cardifolia* (haldu), *Ailanthus excelsa* (maharukh), *Albizia lebbek* (kokko), *Artocarpus heterophyllus* (kathal), *Artocarpaus hirsutus* (aini), *Alstonia scholaris* (chatian), *Anogeissus pendula* (kardahi), *Azadirachta indica* (neem), *Chloroxylon swietenia* (satinwood) *Cinnamomum zeylanicum* (cinnamon), *Diospyrous ebonum* (ebony), *Dysoxylum malabaricum* (white cedar), *Gmelina arborea* (gamarai), *Hardwickia pinnata* (piney), *Juglans regia* (walnut), *Lagerstromia microcarpa* (benteak), *Pterocarpus marsupium* (bijasal), *Sterculia urens* (gular and tapsi), *Toona ciliata* (toon), *Wrightia tinctoria* (ankudu, jeddapaala, tedlapaala), *Pterocarpus santalinus* (red sanders), *Givotia rottleriformis* (puniki) and *Gyrocarpus jacquini* (helicopter tree, propeller tree, stinkwood) (Kumar *et al.*, 1995, 1996a, 1996b).

However, the industry is facing an acute shortage of many of these species due to overexploitation (not exclusively by wooden-toy makers), which is pushing up the prices of the wood and hence of the handicrafts themselves. Squeezed by higher costs, many artisans are abandoning their professions (Kumar *et al.*, 1995).

For example, the artisans of Nirmal and Kondapalli, in the state of Andhra Pradesh, depend on *Givotia rottleriformis* for various types of toys. In Nirmal, the annual requirement for wood of this species is 40 m^3, and 50–60 families derive their livelihoods by using this species for making toys (Rao *et al.*, 2001). However, *Givotia rottleriformis* is becoming scarce because of the overexploitation and degradation of the forest in which it grows. The situation is similar in Kondapalli. The artisans of Ettikoppaka in Andhra Pradesh depend on the wood of a small deciduous tree, *Wrightia tinctoria*. Anecdotal information suggests that nearly 200 families in Ettikoppaka and the surrounding area are dependent on

TABLE 1. Timber species used for toymaking in southern India

Species	State	Population centre
Givotia rottleriformis (puniki)	Andhra Pradesh	Nirmal, Kondalpalli, Tirupathi
Wrightia tinctoria (ankudu, dudhi)	Andhra Pradesh	Nirmal, Ettikopakka
	Karnataka	Channapatna, Sagar
Pterocrapus santalinus (red sanders)	Andhra Pradesh	Chittoor, Tirupathi
Santalum album (sandalwood)	Karnataka	Sagar, Mysore
	Kerala	Thiruvananthpuram
	Andhra Pradesh	Hyderabad
Dalbergia latifolia (rosewood)	Kerala	Thiruvananthpuram
	Karnataka	Mysore
	Tamil Nadu	Tanjavore
	Andhra Pradesh	Rajamundry

Source: Rao *et al.*, 2001

toy making based on this raw material (Rao, Balaji and Joshi, 2011). There is an urgent need for these artisans to shift to alternative species, especially plantation species, because *Wrightia* is becoming scarce.

Our institute has carried out studies of alternative species, now being grown in plantations, that may provide suitable wood for toys and other handicrafts. They include *Acacia auriculiformis* (earpod wattle), *Eucalyptus camaldulensis* (river red gum), *E. citriodora* (lemon scented gum), *E. tereticornis* (mysore gum), *Leucaena leucocephala* (subabul), *Maesopsis eminii* (musizi), *Swietenia mahogani* (mahogany), *Dalbergia sissoo* (sissoo) and *Simarouba glauca* (oil tree) (Kumar *et al.*, 1995; IWST, 2008).

Lack of conservation of genetic resources

Given the shortage of traditional raw materials, there is a need to ensure that a sufficient area of planted forest is available to meet the needs of the traditional wooden-toy industry. Potentially, this industry is a good source of foreign exchange and also a vehicle for maintaining cultural heritage (Rao *et al.*, 2001), as well as a provider of employment and income in rural communities. However, there is little ongoing effort to generate scientific data on the working and carving qualities of tree species that could provide alternatives to Indian woods.

So far, the conservation of the genetic sources of the main Indian tree species used in the wooden-toy industry has not received due attention. There is an urgent need to conserve existing forests, bring these species under sustainable management and afforestation programmes, and encourage the use of alternative plantation-grown species.

With a few exceptions, wooden-toy makers lack sufficient support from research institutions, government agencies and private companies, due to a lack of interaction and political will.

Gender exploitation by traders

Export traders often bypass women during procurement processes, even though many women make export-quality products (group of craftspeople in Chennapatna, personal communication, 2012). This bias may be partly because women mostly use hand lathes and exporters prefer articles made on power lathes (which men are more likely to use than women, and which provide products of more even quality). It may also reflect the continuing low profile in the industry of women, who have traditionally catered to local clients and markets.

Low prices

Artisans complain that while raw-material prices increase, the prices paid for their products remain static. This is partly because of the presence of intermediaries between suppliers and purchasers in export, wholesale and retail markets and partly a function of product substitution and the need for product diversification. As synthetic substitutes flood the market, prices for handmade products cannot be expected to rise unless they acquire a new level of desirability. It is necessary to improve designs and diversify products, which requires new skills and training (Rao *et al.*, 2001).

A SUCCESS STORY

Channapatna, in Karnataka, is home to more than 5 000 skilled craftsmen whose livelihoods are based on wooden-toy making. According to the artisans themselves, they earn Rs 300–350 per day; an income of Rs 5000–6000 per month enables a family to lead a fairly

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decent life in Channapatna (Rao *et al.*, 2001). Some years back, their industry was threatened by a flood of low-cost, plastic "made in China" toys on the market, which quickly replaced traditional handmade wooden toys and jeopardized the livelihoods of the artisans. The industry survived, however, thanks partly to the efforts of the state government and some non-governmental organizations (NGOs), which provided the industry with crucial support. Many artisans who had migrated to other cities in search of employment have now returned to Chennapatna as the industry gains momentum and economic importance. The Karnataka State Handicraft Development Corporation is running a common facility centre, in which artisans pay a small fee to use the facilities. NGOs such as Maya Organics have developed new designs to help the artisans further develop their products. About 1 000 registered members avail themselves of the benefits offered by the Karnataka State Handicraft Development Corporation to encourage the industry, including funds for health schemes and training on new designs, and the government is providing loans to help improve the facilities.

ACTIONS TO MAKE THE INDUSTRY SUSTAINABLE

The following actions are needed to address the problems facing the traditional wooden-toy sector:

- provide technological support and training, including in social and design trends;
- establish training centres to improve the skills base, including in design, manufacture and marketing;
- conserve natural forests used to supply the sector, bring them under sustainable management and, where necessary, reforest them;
- evaluate the working, carving and turning qualities of alternative woods that might substitute for traditional species;
- encourage the use of alternative plantation-grown species suitable for the sector and establish and sustainably manage plantations of them;
- increase the scale of production, depending on the feasible level of sustainable raw-material supply, by providing sufficient infrastructure;
- develop adequate material testing and performance measurement and upgrade production processes to improve the quality and safety of products;
- use innovative marketing to increase reach and build new marketing channels.

One way to increase the profitability of makers of traditional wooden toys would be to cut the middleman from the trade. A mechanism is needed to enable wooden-toy makers to sell their products directly to government and private agencies at a pre-fixed rate. Certain government agencies collect and sell the product of cottage industries through various markets in India's temple towns and through state handicrafts development corporations, such as Leepakhi (Andhra Pradesh), Pumpar (Tamil Nadu) and Cauvery (Karnataka). But to properly support the wooden-toy makers, such agencies need to be strengthened.

THE FUTURE OF INDIA'S WOODEN-TOY INDUSTRY

The Indian middle class has emerged as a major consumer force; its purchasing power is now equivalent to that of the entire European market (Rao *et al.*, 2001). India's wooden-toy artisans create beautiful things. Considering the retail boom and the changing consumption habits of the middle class, which favours the use of toys as a medium for entertainment and education, the wooden-toy industry in India could – if adequately supported – experience major upward growth.

In our view it is the duty of society, which benefits from the artistic creations of the wooden-toy makers, to assist them. The most important factor is the availability and affordability of the raw material with which to practise their craft. A dwindling supply of wood from natural forests has caused an escalation in the cost of the raw material. The problem of raw-material supply can be overcome by using the wood of alternative species, grown in plantations. There is an urgent need to conserve existing forests and bring them under sustainable management and reforestation programmes, and to encourage the use of alternative plantation-grown species. At the same time, wooden-toy makers need assistance to upskill in the face of international competition in the toy market. ◆

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Forests in the next 300 years

J. Blaser and H. Gregersen

FAO/V. MAKSIMOV

"Even if I knew that tomorrow the world would go to pieces, I would still plant my apple tree."

– Martin Luther (early sixteenth century)

The global forest estate will be much larger in 2313, and forest managers will be very important people.

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The oak tree being planted as we write on a cold morning in 2013 at a university campus on the Swiss plateau should reach maturity sometime in the twenty-fourth century. All going well, the sipo tree (*Entandrophragma utile*) that has just established itself in a rainforest gap in northern Republic of the Congo, starting a life of fierce competition for light and nutrients, will overgrow the forest canopy to become an emergent tree sometime after 2350. The fir seedling (*Abies sibirica*) in the Northern Ural of the Russian Federation, which today is 20 cm tall, will have a stem diameter of 60 cm by 2313.

At the global scale, the question of whether individual trees such as these survive to maturity is unimportant, but the overall fate of the forests of which they are part is crucial. Forests and trees are a *renewable* resource, providing an enormous range of goods and ecosystem services. In the face of expected declines in the availability of *non-renewable* resources and massive environmental change, the fate of trees and forests in the next 200–300 years is

Above: The Kaybitsky Forest, the Russian Federation, which houses genetic reserves of oak trees. Maintaining forest biodiversity will be crucial for a sustainable future

of fundamental importance to humanity. Forests come and go (Box 1), but in the last several hundred years there has been a dramatic decline. Nevertheless, there is potential to reverse this and to greatly increase the global forest resource. In this article, we consider the factors that will influence the fate of forests in the next 300 years, and predict a world that is more reliant than ever on its forests – and on its forest managers.

Forests come and go

Fourteen thousand years ago, at the end of the last glacial period, the world's forests were found mainly in refuges in hot and humid Southeast Asia, the central Amazon, West and Central Africa and the southeast of North America (Adams, 1997) and covered an area of less than 2 billion hectares (ha). As temperature and humidity increased, forests expanded to their largest extent of more than 9 billion ha in the mid-Holocene, 7 000–9 000 years ago. From about 3 000 years ago, the forest area declined steadily as humans developed from hunters and gatherers to farmers and herders (Figure 2). We estimate the net loss of forest area since the early 1700s at about 1 billion ha, all of it human-induced. Nevertheless, in the last two decades, 77 countries have changed from being net losers of forests to net gainers, although the forests being added are often quite different from the forests being lost (Putz, forthcoming).

THE MAIN ASSUMPTIONS

The information age[1] is giving rise to dramatic changes in the way in which societies live, think, work, buy and prioritize future investments, and the humans of today are very different – physically, mentally and spiritually – to those of 300 years ago. We assume that people will continue to change and that those who live 300 years from now will differ greatly from us in many ways that we cannot predict. We assume, however, that their fundamental values will remain the same – they will value environmental quality, economic prosperity and social equity.

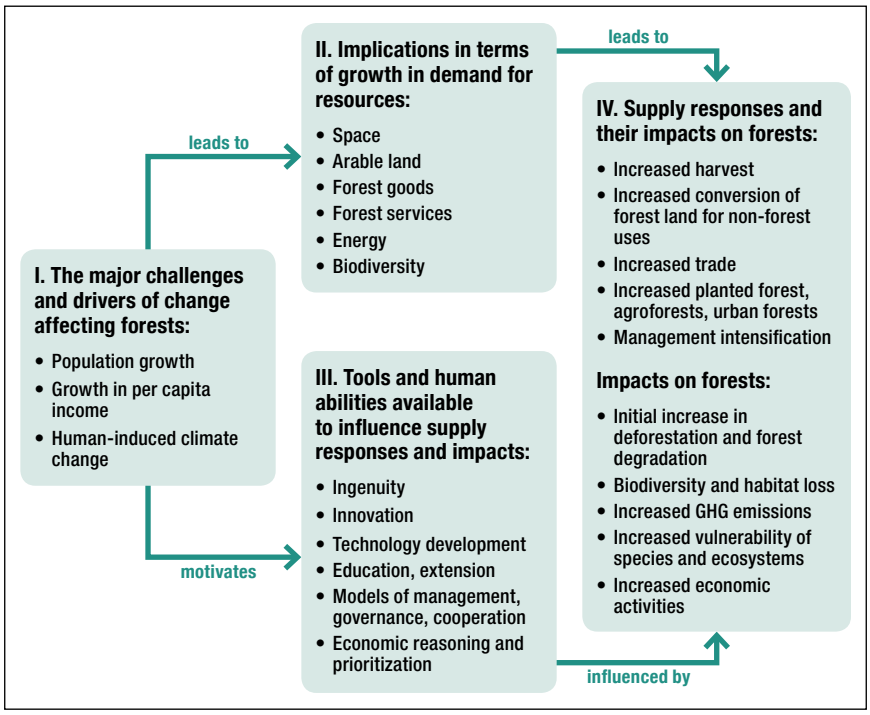
As discussed below, we assume that the overall consumption of resources will increase due to population growth and growth in per capita consumption. At the same time, we expect that climate change will have dramatic impacts on the environment, potentially inducing major movements of people and leading to increased conflict and civil unrest. Forest destruction could continue unabated and even increase over the next decades. In his acclaimed *A Brief History of the Future*, Attali (2011) envisioned that "forests will be rarer and rarer, devoured by the packaging and paper-making businesses and by the expansion of agriculture and cities".

Despite such a potentially bleak medium-term outlook, we choose to accept an equally reasonable assumption; namely, that, despite the many problems humanity will face in the next 300 years, social cohesion will generally be maintained. Societies will become increasingly democratic, research capacity will increase, and nanotechnologies and other undreamed-of innovations will flourish. Three hundred years ago, societies used forests and trees for the same basic reasons we use them today, but in totally different ways. We expect that the same will be true 300 years from now – the same benefits will be reaped from forests, but in many new ways. Below, therefore, we make a case for expanded demand for forests and trees over the next 300 years and therefore for an expanded global forest estate.

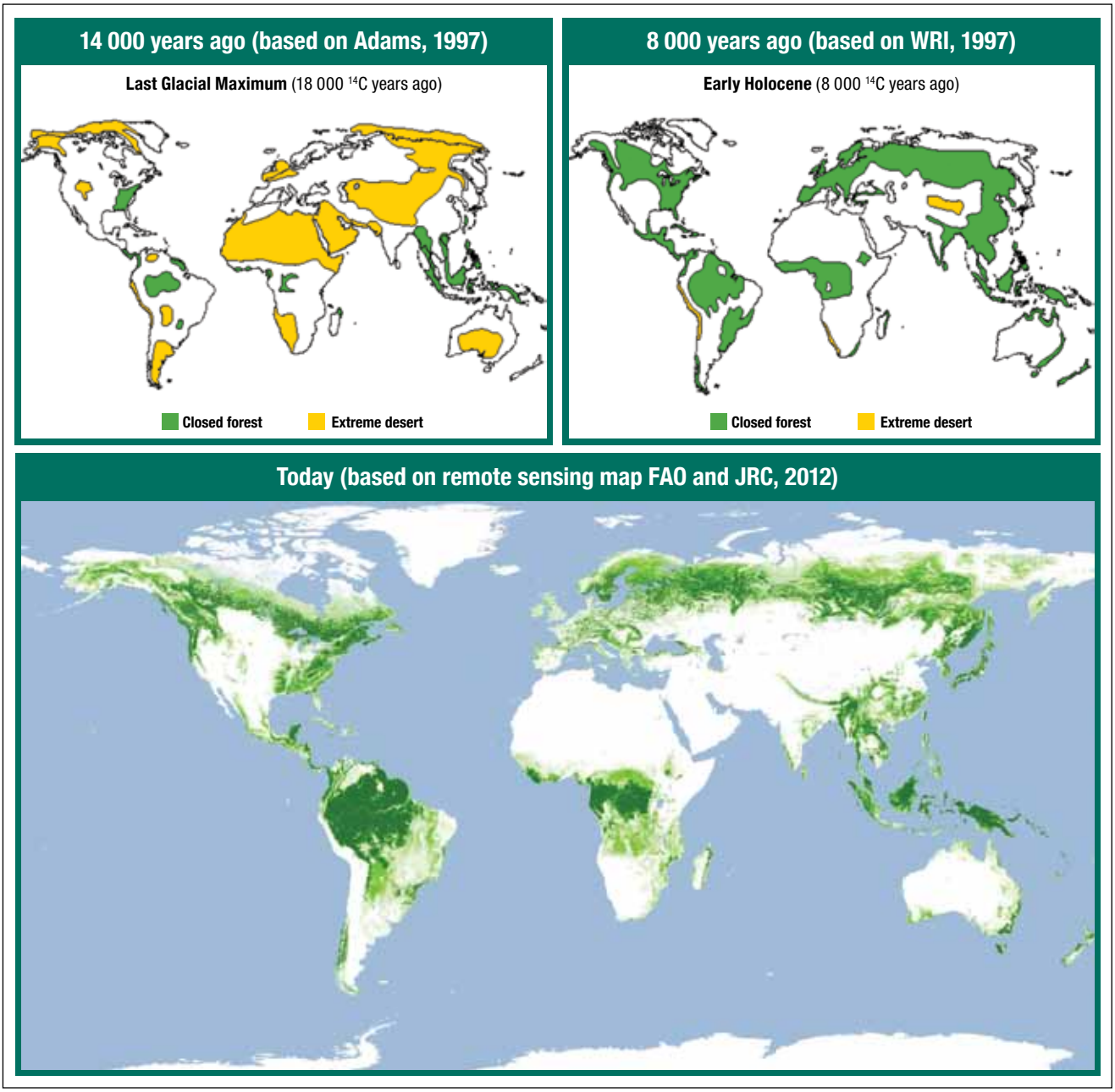
MAJOR CHALLENGES AND A PATHWAY FOR CHANGE

Figure 1 shows the major elements we considered in projecting what will happen to forests in coming centuries. Of the many challenges and drivers (Box I in Figure 1) that will influence forests of the future, we focus on what we view

1
The future of forests: challenges, responses and impacts


I. The major challenges and drivers of change affecting forests:
• Population growth
• Growth in per capita income
• Human-induced climate change
leads to
II. Implications in terms of growth in demand for resources:
• Space
• Arable land
• Forest goods
• Forest services
• Energy
• Biodiversity
leads to
III. Tools and human abilities available to influence supply responses and impacts:
• Ingenuity
• Innovation
• Technology development
• Education, extension
• Models of management, governance, cooperation
• Economic reasoning and prioritization
motivates
IV. Supply responses and their impacts on forests:
• Increased harvest
• Increased conversion of forest land for non-forest uses
• Increased trade
• Increased planted forest, agroforests, urban forests
• Management intensification
Impacts on forests:
• Initial increase in deforestation and forest degradation
• Biodiversity and habitat loss
• Increased GHG emissions
• Increased vulnerability of species and ecosystems
• Increased economic activities
influenced by

[1] The first two "ages" were the agricultural age and the industrial age (Toffler, 1980).


14 000 years ago (based on Adams, 1997)
Last Glacial Maximum (18 000 14C years ago)
Closed forest
Extreme desert
8 000 years ago (based on WRI, 1997)
Early Holocene (8 000 14C years ago)
Closed forest
Extreme desert
Today (based on remote sensing map FAO and JRC, 2012)

2
The world's forest area

as the three most important: population growth; growth in per capita consumption; and climate change. These give rise to many challenges (Box II), but also to many opportunities to meet the challenges by providing incentives for ingenuity and innovation to flourish and leading to the development of new technologies and ways of organizing societies (Box III). Societal priorities, abilities and tools will determine the responses to the challenges, and the responses, in turn, will determine the size and nature of the impacts (Box IV). Each of these four elements (as shown in boxes I–IV) is discussed below.

Major challenges and drivers of change affecting forests

Population growth. The world is getting more crowded. It took about 2 000 years for the world population to grow from 60 million to 600 million people in 1700 (McEvedy and Jones, 1978) and only 300 years to grow almost twelve-fold to 7 100 million in 2012. However, the good news, based on a well-justified "medium growth" scenario, is that the world's population will grow, at a slowing rate, to

around 9 billion by 2050 and then stabilize up to 2300 and beyond (UN, 2004). The growth to 2050 will occur nearly exclusively in tropical and subtropical countries, mainly in Africa and Asia, where deforestation for food production is likely to remain a challenge for the next 50 years. However, the current trend of migration from tropical areas to temperate areas, and from rural to urban areas, is also likely to continue, perhaps mitigating the direct impacts of population growth on forests. A global population of 9 billion people could live sustainably (see, for example, Tudge, 2007), except for expected growth in per capita consumption.

Consumption and income growth. OECD (2012) and The Conference Board (2012) projected that world gross domestic product would continue to grow for the next 20 years or so, with rates of growth higher in developing countries and higher than population growth rates. The consumption of goods and services differs dramatically between poorer and richer countries, both in absolute and relative quantities. According to the Worldwatch Institute (2011), "the 12% of the world's population that live in North America and Western Europe account for 60% of private consumption spending, while the third of the population that lives in South Asia and sub-Saharan Africa accounts for only 3.2%". As per capita incomes increase in developing countries it is likely that resource consumption will also rise.

Income growth will also shift the mix of goods and services demanded from forests. The demand on the world's *natural* forests is likely to increasingly shift away from uses such as fuelwood and timber towards services such as watershed protection, carbon sequestration, biodiversity conservation, recreation and other non-deforesting uses. This increased acknowledgement of the importance of forests is one reason why most developed and middle-income countries are now net adders to their forest areas. Another reason is that some major countries have "exported their deforestation" to mainly developing countries by becoming net importers of food and forest products because they are often cheaper than domestic production (Gregersen *et al*., 2011).

Climate change. Science-based predictions of climate change generally do not go beyond 100 years from now; thus, a projection to 300 years involves many uncertainties. We have chosen an optimistic scenario of an increase in mean global temperature of 4 °C by 2313; this is optimistic because this increase is projected by most climate models by the end of the *current century*, given no serious policy changes (World Bank, 2012a). Despite being

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Mid-altitude (1 500 m above sea level) fire-affected savanna in Madagascar. Under climate change there is a risk that many forested areas today will become savanna-like landscapes, with small islands of biodiversity-rich but isolated forest stands

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Savannah in the Republic of the Congo in October 2012. This could be the landscape in a large part of the Congo Basin in 2313

optimistic, such an increase is projected to have devastating consequences, including the inundation of coastal cities; increasing risks to food production, potentially leading to higher malnutrition; increased aridity in many dry regions and increased rainfall in wet regions; unprecedented heat waves in many regions, especially the tropics; substantially exacerbated water scarcity in many regions; an increased frequency of high-intensity tropical cyclones; and the irreversible loss of biodiversity, including in coral reef systems and forests (World Bank, 2012a).

The 4 °C scenario involves an increase in the mean global temperature from the pre-industrial value of 13.5 °C in 1800 and the 14.5 °C today to about 18.5 °C in 2313. Changes in climate could happen very fast, prompting dramatic changes to forests. When trees, plants and animals are exposed to environmental conditions that differ from those to which they are adapted, the resulting physiological stress makes them more susceptible to catastrophic damage from ecological disturbances such as disease, insects and fire (Bergengren, Waliser and Yung, 2011) and increases the likelihood of local and even regional extinctions. Research to better understand vulnerability and resilience will play a major role in providing forest management options in the face of climate change.

Implications for resource demand

The three major challenges discussed above will lead to increased demand for natural resources and have major implications for the future of forests.

Deforestation and reforestation. If technological progress in food productivity per unit of land does not keep up with the growing demand for food, then there are likely to be significant reductions in forest area as agriculture expands to meet growing demand. Over the next 50 years, much forest and woodland in developing countries will likely be cleared to make room for food and possibly biofuel crops. Thus, deforestation will continue to convert forests to land suitable for agricultural crop production (Bruinsma, 2003). On the other hand, the area of land in agricultural use in the industrialized countries of Europe and North America will actually decrease to 2030, and much of it will revert to forest and other environmental uses (Wirsenius, Azar and Berndes, 2010; Gregersen *et al*., 2011). We expect a similar, if somewhat later, trend in most developing countries.

Watershed management. Freshwater scarcity is likely to become a major constraint to development in coming centuries. Water use and availability are affected by population size, technology development and income growth, and climate change is likely to have an increasing impact. There is evidence that trees can reduce

An old-growth ayous tree in the Sanga forest, Republic of the Congo. Climax forests will dwindle in the face of climate change and will be rare by 2313

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runoff at the small catchment scale and, at a very large scale (e.g. the Amazon Basin), forests are linked to precipitation patterns and water availability (Ellison, Futter and Bishop, 2011). In drier areas, trees can reduce the amount of available water (although through sheltering effects they can also increase local water availability). In the future, such direct links between forests and water will be crucial, and managing forests specifically for water quality and the timing of water flows will be increasingly important.

Biodiversity protection. In past millennia, human societies used hundreds of plant and animal species to ensure their food and health security. Today, however, global food security depends on only a few crop species (Salim and Ullsten, 1999) and genetically narrow high-yielding varieties, increasing the vulnerability of food production to biotic and abiotic stresses. The risk of crop failure will increase further with climate change and the increasing fragmentation of habitats. Conserving biodiversity, particularly in tropical dry and moist forests, should be a top priority for humanity because genetic diversity will be essential as a buffer against changing environmental conditions and as a pool of variation to be used in crop and forest tree improvement and breeding.

The permanence of carbon stocks. Besides oceans, sediments and fossil fuels, forests, tundra and peatlands constitute the planet's main carbon pools (about 2 000 gigatonnes). Ensuring the stability of forest carbon stocks will be a major challenge for foresters. REDD+[2] was first proposed in 2007 as a mechanism to reduce greenhouse gas emissions from forests, and there are high expectations that it will become a major tool for funding forest management. However, there is considerable work to do to put this or other similar mechanisms into effect and to ensure the permanence of forest carbon.

Wood energy. Oil, gas and coal are exhaustible resources; the first two will likely be almost exhausted in 300 years,

[2] A term that has come to mean reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.

but coal may last longer. Addressing the energy challenge will be a priority in a hotter and more crowded world. Wood was the main source of energy before the nineteenth century and continues to be an important energy source. In 2009, about 1.7 billion m^3 of wood was consumed as fuel, amounting to 73 percent of the world's renewable energy supply in that year (IEA, 2010). Third-generation biofuels[3] will become increasingly important, but most other types of wood-based energy are likely to decline.

Wood as a raw material. The global consumption of industrial roundwood was about 1.9 billion m^3 in 2009 and is projected to grow to 3 billion m^3 by 2050 (FAO, 2010). The consumption of wood for industrial purposes and as a biofuel will increase in the next 30–50 years. Beyond that, wood fibre will play an increasingly major role as a raw material for composite products and as substitutes for petroleum-based materials, with a vast range of applications in medicine, electronics, biomaterials and energy. Wood and many other forest products are recyclable, another factor in their favour. The bottom line is that wood will likely continue to be important, and indeed will increase in importance, as we move toward 2313.

Tools and human abilities will influence supply responses and impacts

Human societies are ingenious, inventive and creative, once the incentives present themselves. Societies can apply systematic approaches to discovery and innovation and use research, development and education to produce workable new technologies and applications. It has also proved possible to change human behaviour, at both the sociopolitical and individual levels; for example, increasing the rights of local communities and citizens to, and responsibilities for, public-domain forest resources can lead to more sustainable forest use and management. Most of the major innovations that will be needed to secure a positive forest future must occur outside the forest sector; they include advances in food production to increase productivity per unit area of land to help reduce deforestation, energy technologies that move away from inefficient fuelwood use, and the development of means to deal with the threat posed by climate change.

Advances in forest science and knowledge. There is no technical reason why the goals of sustainable forest management (SFM) cannot be achieved in all forest biomes. In the past 300 years, forest management systems have been developed in most biomes that mimic nature, and there is a good understanding of the regeneration of many forest-associated plant and animal species. Nevertheless, climate change represents a major challenge for forest scientists: climax forests are at high risk; successional forests with fast rotational cycles may take over in many areas because of extended droughts, forest fires and other extreme events; and many tree species might not reach maturity due to physiological stress and the increased frequency of disturbance. Forest science must enable a better understanding of forest vulnerabilities and stressors and develop implementable solutions to the challenges posed by climate change.

Technology development. Much effort will be needed to develop technologies based on renewable resources such as trees that are cost-efficient and environmentally friendly. Wood has huge potential as a raw material, and the genetic improvement of commonly used tree species could make it even more versatile. Genetic modification is contentious; nevertheless, as the risks become better evaluated, and as competition for land intensifies, the practice of genetic modification is likely to become more frequent for both agricultural crops and trees. Overall, continual innovation in forest products is needed to ensure the economic viability of production forests.

Governance and management. The main governance challenges in the future will be linked to access to crucial natural resources such as land, forests, water, energy and minerals. Good global governance will be required to avoid devastating conflicts and disputes over resources, particularly water in transboundary situations but also land. Human migration towards areas with the best living conditions is likely to increase in the coming century. We expect that the current governance structure will change towards a more comprehensive, resource-based approach with greater focus on resource access. The present trend to provide forest communities and indigenous groups in developing countries with statutory legal rights and responsibilities will need to continue. New institutional arrangements for making payments for and managing ecosystem services will be needed.

Intersectoral governance will also require greater attention. Multifunctional solutions that optimize the use of a given landscape will be needed to address, for example, integrated climate change mitigation and adaptation, energy generation, freshwater protection and ecosystem resilience. Securing a permanent forest estate is likely to be a significant challenge: potentially, some of the best future living areas for humanity will be where forests are growing now.

Global cooperation and policy processes. It seems obvious that existing global arrangements on forests will be insufficient, even to tackle forest-related issues over the next 20 years or so. How to address the current void is a crucial policy challenge. New international agreements dealing with issues such as international land-grabbing may be required. There is a need for stronger emphasis on compliance and enforcement in many forest-related agreements, including the multilateral environmental agreements. Strong regional and global technical and scientific institutions with clear mandates to address environmental, sociopolitical and economic challenges across national boundaries will be needed.

[3] Third-generation biofuels are made from algae and other microorganisms dealing, among other things, with the degradation of lignocellulose, hemicellulose and lipid-rich materials.

THE SUPPLY RESPONSE: IMPACTS ON FORESTS

Overall, we expect a greatly expanded demand for forest and tree goods and ecosystem services. Table 1 indicates likely possible supply responses to this increased demand.

A crucial supply response will be to maintain natural forests for their increasingly valued ecosystem services, including biodiversity and the permanence of carbon stocks, and to reduce extractive uses of them. To meet increasing demand for wood and wood fibre, planted forests, assisted natural regeneration, the restoration of degraded forests and the rehabilitation of degraded lands will all increase in importance (Poore, 2003). Forests will become much more important as a source of fibre and for their ecosystem services, and increasingly they will become

TABLE 1. Possible management and supply responses and their impacts on forests to 2313

	Now to 2100	2100 to 2200	2200 to 2313
Deforestation due to overexploitation for wood and to provide land for other priority uses	+++ → + Continuous deforestation in the tropics, with some success in reducing it over time through REDD+ and new, holistic forest programmes	+ → -- Reduced large-scale, human-caused deforestation but increased climate change-based disturbances. Forest area increases in the majority of countries	-- → --- Human-made forests managed sustainably become much more important. Most remaining natural forests are in protected reserves
Land degradation	++ → +++ Increased degradation of arable land, mainly in tropical least-developed countries. Restoration of degraded lands in developed world	+++ → ++ Continuous degradation due to climate change, but increased restoration of degraded land due to increased land value	++ → + Land degradation remains an issue, but ways of reclaiming lands are much improved. Intensive restoration programmes are in place
Biodiversity and habitat loss	++ → +++ Continued loss of biodiversity and habitats in all biomes, slowing towards the end of the period	+++ → ++ Continuing loss, mainly due to climate change and invasive species increasing in all forest biomes. Intensive conservation programmes are in place	++ → - Stabilization and partly artificial regaining of habitats and biodiversity
Vulnerability of species and ecosystems	+ → ++ Gradual increase in vulnerability in all biomes	++ → +++ Gradual increase in vulnerability in all biomes; management systems are developed to minimize threats	+++ → +++ Continued threat, particularly in marginal areas; management systems are developed to minimize threats
Harvesting and use of forest products	+ → ++ Increased use of and trade in timber, wood products, fuelwood and non-wood products	++ → +++ Shift of production towards higher-end uses of wood fibre and derivates; increase in trade based on comparative advantage	+++ → +++ Wood fibre and non-wood forest products of great importance for materials of all kinds; most wood supply is from planted forests
Natural forests	++ → ++ Integrated management in temperate and boreal zones, less so in the tropics	++ → +++ Shift in emphasis of natural forest management towards the provision of ecosystem services	+++ → +++ Conservation management of natural forests; sophisticated, human-induced forest protection systems
Planted forests, agroforests and urban forests	+ → ++ Landscape forestry: steady growth in all biomes; increased domestication of tree species; development of genetically modified organisms for major planted species	++ → +++ Large-scale commercial afforestation, reforestation and agroforestry are practised more widely	+++ → +++ Comprehensive approach involving improved management systems and urban forestry; the focus is on human-made forests of genetically improved trees
Watershed and soil protection	+ → ++ Integrated through REDD+ and payments for ecosystem services; landscape-level management systems are evolving	++ → ++ Landscape management is an intensive, integrated, well-accepted approach in all biomes	++ → ++ The capital-intensive management and protection of landscapes are priorities
Carbon sequestration, ensuring the permanence of carbon pools	- → ++ Weak approaches through climate-change mitigation instruments, including REDD+ and nationally appropriate mitigation approaches	++ → +++ Increased consideration of carbon as a co-benefit of SFM	+++ → +++ The permanence of carbon pools is ensured through SFM
Other non-use values, such as climate protection and spiritual and recreational values	+ → + Recognized by stakeholders, but politically undervalued	+ → ++ Recognized as highly important local and global externalities	++ → ++ Considered among the main values of forests and a primary focus of SFM

Note: + and – indicate the level of importance and change of a management or supply response at the beginning and end of a period.

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A eucalypt plantation in India in 2008. Intensive wood-fibre production will be an important element in the future

economically competitive with agriculture. Degraded lands will become more valuable, including for planted forests.

WHAT FUTURE FOR OUR FORESTS?

Extent of forests in 2313

Table 2 shows our estimate of the extent of the world's forest estate in 2313 at about 5 billion ha. The point here is not so much the exact increase over today (1.2 billion ha), but rather the expectation that tree cover will expand and be more important in the future as a renewable resource with great versatility, and that the increase will be almost entirely due to increases in planted and assisted natural regeneration forests, agroforestry systems and urban forests. Although competition for land is a significant issue today, we expect there to be sufficient land available for such an expansion of forests. Agricultural crops will increasingly be produced using intensive production systems (often under-roof), there will be more urban agriculture, and meat will be produced much more efficiently. However, while we expect the gross area of available land to be sufficient, it will be of variable quality and much of it will require restoration.

Christophersen (2010) suggested that there are more than 1 billion ha of clear-cut or degraded forest land worldwide. Forests could be re-grown on most of that land if demand for forests and trees increases and the economics of restoration become more favourable. Looking at the requirements for effective large-scale restoration, Menz, Dixon and Hobbs (2013) proposed a four-point plan to ensure that restoration sustains and enhances ecological values: identify focal regions with high restoration demands; identify knowledge gaps and prioritize research needs to focus resources on building capacity; create restoration knowledge hubs to aggregate and disseminate knowledge at the science–practice interface; and ensure political viability by ensuring recognition of the economic and social values of functioning restored ecosystems. These points are interrelated and may occur in parallel. In nearly all cases, replanting would not replicate the former forest in either carbon density or biodiversity but would provide a wide range of benefits.

We do not foresee a linear expansion of forest cover over the coming 300 years. Large-scale forest destruction, focused in the tropics, may well continue to 2050. Then, or fairly soon thereafter, a turning point will be reached at which policy efforts to stop deforestation on natural forest lands start to bite. Recovery will happen fast, but unevenly worldwide.[4] Below, the main forest biomes are discussed.

[4] A good example of what is possible is the rapid greening of the Republic of Korea in the period 1960–1980 through a large-scale replanting and community forestry programme made possible when thousands of villages were given secure rights to the outputs of their planting efforts (Gregersen, 1982, 1988; Lee, 2012).

TABLE 2. Forest distribution, by broad type, 2013 and 2313

Forest cover, 2013					**Total**
Primary forests, economically inaccessible or geographically too remote for intensive use (mainly boreal and tropical forests; also forest protected areas)	**Forest/landscape mosaic**, accessible forests including degraded forests and secondary/ successional forests (mainly in the tropics), used primarily for fuelwood and timber	**Well-managed (semi) natural forest**, including natural and semi-natural secondary forests (mainly boreal and temperate forests)	**Planted forests** – afforestation and reforestation for production and/or protection purposes (all regions)	**Agroforestry and trees in landscapes**, including urban forests and scattered parks in urban areas (all regions)	
< 800 million ha	**> 1 900 million ha**	**> 700 million ha**	**< 300 million ha**	**< 100 million ha**	**3.8 billion ha** (29% of total land area)
Expected forest cover, 2313					**Total**
Natural forests, close-to-pristine but considerably affected by climate change; predominantly successional rather than climax forests. Almost entirely with protected status	**Forest/landscape mosaic**, with naturally grown forests in patches in dry landscapes (e.g. along rivers); managed predominantly for carbon and biodiversity, often by smallholders	**Intensively managed and controlled assisted natural regeneration forests and planted forests**, including high-yielding clonal forests, combined with semi-natural forests for fibre for various uses such as construction, furniture, bioplastics, paper, clothing and nanotechnology applications and for energy		**Urban forests and trees, and agroforestry**, for local climate, air-quality, water and recreational values, and occasional use of wood fibre	
< 500 million ha	**> 1 000 million ha**	**> 3 000 million ha**		**> 500 million ha**	**5.0 billion ha** (38% of the total current land area)

Source: Data for 2012 based on FAO and JRC, 2012; Blaser *et al*., 2011; Forest Europe, UNECE and FAO, 2011. Note that FAO (2010) estimated the global area of primary forest in 2010 at 1.36 billion ha.

In the **tropical moist biome**, population and income growth will influence land and forest use, particularly in Africa and Southeast Asia, to 2100. It can be expected that considerable parts of the tropical moist forests in the Congo Basin, which are relatively accessible, will be converted to agricultural land (World Bank, 2012b). The Amazon Basin, the Mekong and some of the major islands of Indonesia will also experience considerable forest loss in the coming 50–100 years to make way for commercial crops to meet worldwide demand for food, fodder and bioenergy. Climate change will become a major issue in these regions, not only for forests but also for agricultural production. Biodiversity and habitat loss will accelerate, and there is a risk of complete land degradation, particularly in the Congo Basin, where a savannah/forest mosaic could become the major landscape feature, and in lowland Southeast Asia. Beyond 2100, on the other hand, most of the predicted reforestation will take place in the tropics, where fast-growing tree species can rapidly sequester carbon and produce fibre.

Tropical dry biomes are likely to have different pathways: some regions will receive more precipitation and humidity (e.g. the Sahel), and some will be more at risk of extended drought due to changing atmospheric circulation (e.g. the monsoon areas of eastern Africa and India). Semi-arid and semi-humid tropical forests, including on the Indian subcontinent and in parts of Central America and southern South America, will be among the most vulnerable forest ecosystems, due to extreme events. Overall, tropical dry biomes will expand in area but tree cover is likely to reduce.

Temperate biomes will host natural forests with the best chance of adapting to major climatic changes and with most hope of ensuring the permanence of carbon stocks. In some regions, forests in temperate biomes will expand into the boreal zone. In Europe, for example, dominant tree species such as beech (*Fagus silvatica*) and various temperate-zone species of oak (*Quercus* spp.) and pine, among others, will expand from the Mediterranean area to southern Sweden and from the extreme west to the Ural in Russia. This will allow interchanging ecotypes under projected climate change as planned adaptation measures.

What today is the core area of the **boreal forests** will become vulnerable due to the increased frequency of summer drought and mild winters (Barnett, Adams and Lettenmaier, 2005) and more frequent and intense fires. In the transitional area in the south, however, deciduous tree species might take up niches left by dying conifer forests. In the transitional areas towards the north (tundra), conifer forests will expand northward, although only slowly and without any major increase in global biomass, carbon or wood supply. There will be new successional forests in Siberia, Alaska and Greenland, although these slow-growing forests will have had relatively little effect on solving global problems by 2313.

Forest quality

While human-induced forest degradation is an issue today and will be for the next 50 years, climate change will have

the biggest effect on forest quality in the longer term. In a world with an average temperature of 18 °C, biomass-rich climax forest types in all forest biomes will be replaced by successional forests characterized by lower biomass and lower carbon stocks and often also by lower biodiversity. Nevertheless, those forests will have to fulfil the same functions as forests today; thus, there will be a need for more forest, at least to secure permanent carbon stocks. A challenge will be to address forest vulnerability, including to wildfire and pests and diseases, and to restore degraded forest ecosystems. Another will be to ensure that forest cover is a competitive land use – otherwise it will not expand as we predict. New forest management approaches may be required (see below), and all the ecosystem services provided by forests will need to be monetized.

Development of planted forests, agroforests and urban forests

There are many legitimate concerns about the potential harmful ecological, social and economic impacts of planted forests, but sufficient experiences have accumulated to avoid such negative impacts in the future (Evans, 2009). In our prediction for 2313, there will be 3 billion ha of intensively managed planted and assisted natural regeneration forests, of which about 2 billion ha will be planted forests for the production of wood and non-wood goods and services, including watershed and soil protection, recreation and carbon sequestration. In the future, large areas of degraded land will be afforested and reforested through community, private and government efforts. There is huge potential for the domestication of a wide range of light-demanding species, particularly in tropical areas, in genera such as *Ochroma*, *Schizolobium*, *Terminalia*, *Trema* and many others, and genetic improvement of already widely planted genera such as *Acacia*, *Eucalyptus*, *Cunninghamia*, *Picea*, *Pinus*, *Populus* and *Tectona*. Wood yields and ecological resilience can be greatly increased by genetic improvement, site–species matching and silviculture. Ways will be needed to increase the diversity and biomass of other associated plants and fauna. Urban forestry will become increasingly important for improving the liveability of city environments and performing a wide range of ecosystem and social services.

Coppice forest management system of beech (*Fagus silvatica*) in The former Yugoslav Republic of Macedonia, 2012. This kind of resilience-based management for wood-fibre production will be widespread in 2313

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What kind of management will be in demand for sustaining forests?

As natural forests become more vulnerable and fragile due to the fast pace of change, especially climate change, maintaining the production of forest goods and ecosystem services will likely depend increasingly on human interventions and ingenuity. Science and governance reform will have important roles to play. Specialized forestry and forest products professionals will be required in disciplines such as biology, silviculture, physiology, genetics, soil science, entomology, biochemistry, nanotechnology, information technology, urban forestry, landscape management and resource economics. While there will be a need for highly skilled forestry professionals, there will also be much more locally based management that makes full use of local and traditional knowledge and interdisciplinary research and interactions. Forest managers will also need exemplary social skills, including in conflict management.

Forest governance, management and policy development will face many serious challenges in the future. Optimizing a variety of objectives in management, including new issues such as the resilience of tree species, securing carbon pools and optimizing materials production based on wood, will demand new approaches to forest management. Some "new" forms of forest management could be derived from the past. In Central Europe, for example, *hochwald* (high forest) systems might need to be converted from even-aged stands to uneven-aged stands or to coppice systems as a way of reducing vulnerability to environmental change and changing economic objectives. In tropical forests, managing young secondary forests in combination with enrichment plantings might lead to new forms of short-rotation forestry, where a maximum of biodiversity can be conserved and an optimal level of biomass can be maintained. Above all, forest managers will need to be versatile and adaptable as they develop and implement new forest management approaches that respond best to changing conditions.

CONCLUSION

With their huge protective and productive functions, forests will play a crucial global role in the next 300 years and beyond. Knowledge of the art and practice of sustainably managing forests will be in high demand. As one of the main renewable natural resources available to humanity, forests will be expected to help mitigate climate change, protect soil and water, provide clean air, conserve biodiversity, help maintain the mental health of humans, and produce wood fibre and other products. Thus, in 2313 we expect that:

- Natural forests will still exist but, to a great extent, climax forest types, such as primary rainforests, will have disappeared, due mainly to shorter forest cycles caused by increased (climate-related) disturbance. We expect that natural forests will cover about 0.5 billion ha, mainly in boreal and temperate areas in Europe, Siberia and North America, and in the tropics (mainly the Amazon Basin and the mountainous areas of Borneo and New Guinea). They will mostly be in protected areas, with minimal timber harvesting, and will provide important ecosystem services. Legal reforms will ensure that indigenous communities maintain their cultural associations with such forests.
- Planted and semi-natural forests, as readily renewable natural resources, will be providing huge quantities of wood and wood-based fibre. Urban forests will be providing recreational and spiritual benefits and serving as climate buffers.
- Overall, the forest area will have increased to about 5 billion ha, although those forests will have less biomass per unit area than natural forests today. The life cycles of forests and tree species will become shorter and they will be subjected to a constant dynamic of climatic and biotic disturbances.
- Forest governance, at the regional and global levels, will still be a key issue. The redistribution of ownership and better defined rights and responsibilities will increase efforts to protect, invest in and use forest resources wisely.

The scenario described in this article is an optimistic one (although some elements, such as the loss of primary forests, are depressing), but it is not an impossible or even an improbable one. It is likely that the oak tree on the Swiss plateau, the sipo tree in northern Congo and the fir tree in western Siberia will not see the beginning of the 24th century, but forests – albeit different to today's – will have spread. Humanity's future will depend in large measure on how it deals with its forests. There is still time and the ability to implement SFM. Today's and tomorrow's foresters have much work to do.

ACKNOWLEDGEMENTS

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FAO/G. NAPOLITANO

International Conference on Forests for Food Security and Nutrition

The International Conference on Forests for Food Security and Nutrition was organized by FAO in partnership with Bioversity International, the Center for International Forestry Research, the World Agroforestry Centre and the World Bank and held at FAO headquarters on 13–15 May 2013. This technical meeting was attended by more than 400 participants, comprising experts from governments, civil-society organizations, indigenous and other local communities, donors and international organizations in more than 100 countries. A summary of discussions was tabled and commented on by participants in the final plenary session.

The next edition of *Unasylva* will feature articles based on conference presentations, discussions and background information.

FAO/S. DIALLO

Above: Gabriel Tchango, Minister of Water and Forests, Gabon, speaks at the opening session of the International Conference on Forests for Food Security and Nutrition

Left: Beneficiaries of the FAO Acacia Tree Project in Senegal hold a village meeting on gum Arabic, an income-earning product from trees. Training in the management of sustainable forest enterprises can help communities, particularly women and youth, gain access to equitable value-chains and improve their food security and nutrition

EARTH NEGOTIATIONS BULLETIN/F. DEJON

Mahir Küçük, Deputy Under-Secretary-General, Ministry of Forestry and Water Affairs, Turkey, and Jan McAlpine, UNFF Director, at the close of UNFF 10

Tenth session of the United Nations Forum on Forests

The tenth session of the United Nations Forum on Forests (UNFF 10) was convened in Istanbul, Turkey, on 8–19 April 2013, focusing on the theme "forests and economic development" and involving nearly 1 300 participants.

Delegates, including ministers and heads of delegation, took part in a ministerial segment on 8–9 April. This included a high-level opening session featuring, among other things, a statement by the Prime Minister of Turkey, Recep Tayyip Erdoğan. Mr Erdoğan said that global population growth and the deterioration of the global environment were creating new economic and social gaps and widening existing ones between regions, countries, peoples and individuals. "If we insist on this relentless competition, ambition and greed, there will be no world for our children to inherit," he said.

A multistakeholder dialogue took place on 10 April, providing an opportunity for inputs by representatives of the Major Groups, comprising women; farmers and small forest landowners; forest workers and trade unions; scientific and technological communities; non-governmental organizations; children and youth; indigenous peoples and industry. The remaining agenda items were opened in plenary on 11 April.

Work on the UNFF 10 outcome took place in two working groups (WGs), which convened on 12–19 April. WGI addressed agenda items on: the assessment of progress made in the implementation of the Non-legally Binding Instrument on All Types of Forests and towards the achievement of the four Global Objectives on Forests; regional and subregional inputs; forests and economic development; and enhanced cooperation and policy and programme coordination, including the provision of further guidance to the Collaborative Partnership on Forests. WGII addressed agenda items on the means of implementation (MoI) for SFM, emerging issues, and the Forum Trust Fund. The "Resolution on Agenda Items 3, 4, 5 and 8" and the "Resolution on Emerging Issues, MoI and the Forum Trust Fund" were adopted by acclamation on Saturday 20 April.

UNFF 10 featured many events organized in the margins of the session. Participants at one of these, on forests and landscape restoration (FLR), co-organized by the Forest Service of the Republic of Korea, FAO and the International Union for Conservation of Nature, learned about FAO's plans to create the FLR Mechanism, to be supported by the Republic of Korea, and heard about that country's successful forest rehabilitation efforts. Private-sector involvement in FLR and the roles of the Global Partnership on Forest and Landscape Restoration, the International Model Forest Network and the Asia Forest Cooperation Organization were also discussed.

Five "forest heroes" from Brazil, Puerto Rico, Rwanda, Thailand and Turkey were recognized at UNFF 10 for their outstanding contributions in support of forests, their communities and around the world. FAO Forestry Department Assistant Director-General Eduardo Rojas-Briales sat on the jury for the awards. The winning photographs of the first International Forest Photograph Contest, and the winning films in the Short Film Festival, were also showcased at the awards ceremony.

An FAO-organized side event on pilot experiences in implementing the Non-legally Binding Instrument on All Types of Forests (NLBI) provided a platform for four countries – India, Liberia, Nicaragua and the Philippines – to share their experiences of FAO-supported implementation. The NLBI was adopted by the UNFF in 2007 to boost the implementation of SFM.

Adapted from Earth Negotiations Bulletin*, 13(187), Monday, 22 April 2013, and other sources.*

Better coordination in timber trade instruments needed

Better coordination and sharing of experiences among nations in implementing anti-illegal timber legislation is needed to ensure a move to responsible trade in timber products, according to participants at the first Global Timber Forum, which was co-organized by FAO, the European Timber Trade Federation and the Forest Trust/Timber Trade Action Plan and held at FAO headquarters in May 2013.

Forum participants also agreed that responsible timber trade plays a key role in sustainable forest management by providing a commercial incentive to retain and increase tree cover and intensify forest productivity.

Over 80 delegates from 40 countries, including representatives of industry organizations and private-sector companies, attended the two-day meeting to increase understanding of sustainable sourcing and the use of timber in green building; share market expertise; and develop solutions to ensure inclusive and legal trade in timber and timber products. Importantly, this first Global Timber Forum provided a platform for sharing experiences on applying the new trade instruments to curb illegal trade, such as those in the European Union, the United States of America and Australia.

The meeting in Rome concluded that the Global Timber Forum should seek to formulate a Commitment Charter, followed by a long-term work plan with a revolving secretariat and an advisory board. Regional focal points were nominated for that end, from all six continents and including China.

André de Boer, Secretary General of the European Timber Trade Federation, said his organization would underwrite the initial development of the Global Timber Forum. The goal would then be to secure wider industry sponsorship in the form of partnerships, also including international specialized organizations in this field.

For more information contact: Jukka Tissari, FAO Forestry Department (Jukka.Tissari@fao.org), or André de Boer, the European Timber Trade Federation (aideboer50@gmail.com).

IUFRO 2014 WORLD CONGRESS

SUSTAINING FORESTS, SUSTAINING PEOPLE
THE ROLE OF RESEARCH

The XXIV IUFRO World Congress

The United States of America is delighted to host the 24th World Congress of the International Union of Forest Research Organizations (IUFRO) in Salt Lake City, Utah, USA, on 5–11 October 2014. Join scientists and professionals from around the world to share research and learn from one another's experiences around the Congress title of *Sustaining Forests, Sustaining People: The Role of Research*.

The 2014 World Congress in Salt Lake City will feature:

- 5 world-class plenary speakers
- 15 sub-plenary speakers
- 150 outstanding technical sessions featuring more than 2 000 oral and poster presentations
- Spectacular field trips
- An informative trade exhibition
- An exciting companion programme.

The Congress will focus on seven themes:

- forests for people
- forests and climate change
- forest biomass and bioenergy
- forest biodiversity and ecosystem services
- forest and water interactions
- forests and forest products for the future
- forest health in a changing world.

Key dates

- July 2013 to October 2013 – call for abstracts
- November 2013 – registration opens
- October 2014 – IUFRO World Congress

The 94th Annual Convention of the Society of American Foresters will be held simultaneously at the same venue, bringing an additional 1 500 forest land managers and decision-makers to Salt Lake City.

To learn more about the World Congress, including information on the process for submitting session proposals and abstracts, or to become a sponsor or exhibitor, visit www.iufro2014.com.

A limited number of scholarships are available through the Scientist Assistance Program. Learn more at: http://iufro2014.com/registration/scientist-assistance-program.

Monitoring soil carbon

Soil carbon monitoring using surveys and modelling: general description and application in the United Republic of Tanzania. R. Mäkipää, J. Liski, S. Guendehou, R. Malimbwi & A. Kaaya. 2012. FAO Forestry Paper No. 168. Rome, FAO. ISBN 978-92-5-107271-4.

Forest soils constitute a large pool of carbon and the release of carbon from this pool through deforestation or forest degradation may significantly increase the concentration of greenhouse gases in the atmosphere. Reliable estimates of soil organic carbon stock and stock changes are needed for REDD (reducing emissions from deforestation and forest degradation in developing countries) and for reporting on greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

This publication describes the application of survey-based and modelling-based methods for monitoring soil organic carbon stock and its changes on a national scale. It presents a design of the first inventory of soil organic carbon, including a discussion on factors that affect the reliability of carbon stock estimates; and a design of a modelling-based approach, including links to national forest inventory data and a discussion on alternative soil organic carbon models. Both approaches can provide information on soil carbon changes for national greenhouse gas inventories.

Also available online: www.fao.org/docrep/015/i2793e/i2793e00.htm.

Remote sensing for global forest change

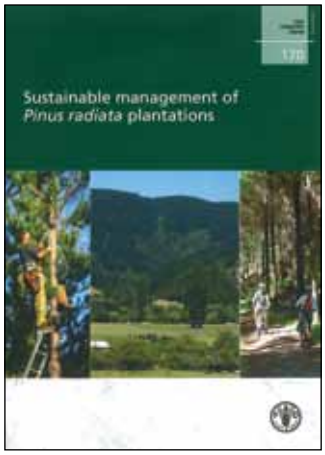
Global forest land-use change 1990–2005. FAO & European Commission Joint Research Centre. 2012, written by E.J. Lindquist, R. D'Annunzio, A. Gerrand, K. MacDicken, F. Achard, R. Beuchle, A. Brink, H.D. Eva, P. Mayaux, J. San-Miguel-Ayanz & H-J. Stibig. FAO Forestry Paper No. 169. Rome, FAO. ISBN 978-92-5-107399-5.

This report presents the key findings on forest land use and land-use change between 1990 and 2005 from FAO's 2010 Global Forest Resources Assessment Remote Sensing Survey. It is the first report of its kind to present systematic estimates of global forest land use and change.

The Remote Sensing Survey used remote sensing data to obtain globally consistent estimates of forest area and changes in tree cover and forest land use between 1990 and 2005. It found that there was a net decrease in global forest area between 1990 and 2005, with the highest net loss in South America. While forest area increased over the assessment period in the boreal, temperate and subtropical climatic domains, it decreased by an average of 6.8 million hectares annually in the tropics. The survey estimated the total area of the world's forests in 2005 at 3.8 billion hectares, or 30 percent of the global land area.

This report is the result of collaborative work by staff at FAO and the European Commission Joint Research Centre, with inputs from technical experts from more than 100 countries. Many of these contributors now constitute a valuable global network of forest remote sensing and land-use expertise.

Also available online: www.fao.org/docrep/017/i3110e/i3110e00.htm.



Consolidating knowledge on an important species

Sustainable management of Pinus radiata *plantations.* D. Mead. 2013. FAO Forestry Paper No. 170. Rome, FAO. ISBN 978-92-5-107634-7.

Pinus radiata (radiata pine) is a versatile, fast-growing, medium-density softwood that is suitable for a wide range of end-uses. Its silviculture is highly developed and is built on a firm foundation of over a century of research, observation and practice.

Radiata pine is often considered a model for growers of other plantation species. This book explores current knowledge of, and experiences with, radiata pine plantation management and examines its long-term sustainability.

Radiata pine management needs to integrate the biological aspects of tree-growing with socio-economics, management objectives, practical considerations and other constraints and opportunities. Although stands of radiata pine may appear simple, they are actually complex ecosystems because they contain large, long-lived trees that change dramatically over time and interact in changing ways with the environment and other organisms.

The focus of this book is on the principles and practices of growing radiata pine sustainably. It also looks ahead to emerging challenges facing radiata pine plantation management, such as the effects of climate change, new diseases and other threats, and meeting changing product needs and societal demands.

Also available onlline: www.fao.org/docrep/018/i3274e/i3274e00.htm.

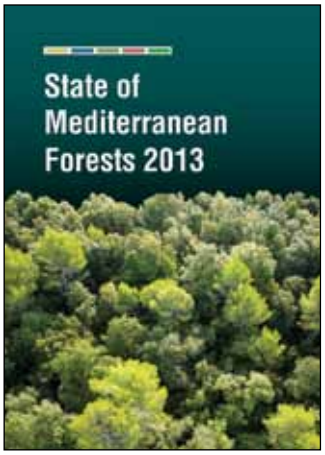
Insects on the menu

Edible insects: future prospects for food and feed security. FAO and Wageningen University and Research Centre. 2012, written by A. van Huis, J. Van Itterbeeck, H. Klunder, E. Mertens, A. Halloran, G. Muir & P. Vantomme. FAO Forestry Paper No. 171. Rome, FAO. ISBN 978-92-5-107595-1.

Edible insects have always been a part of human diets, but in some societies there remains a degree of disdain and disgust for their consumption. Although the majority of consumed insects are gathered in forest habitats, mass-rearing systems are being developed in many countries. Insects offer a significant opportunity to merge traditional knowledge and modern science to improve human food security worldwide.

This publication describes the contribution of insects to food security and examines future prospects for raising insects at a commercial scale to improve food and feed production, diversify diets, and support livelihoods in both developing and developed countries. It shows the many traditional and potential new uses of insects for direct human consumption and the opportunities for and constraints to farming them for food and feed. It examines the body of research on issues such as insect nutrition and food safety, the use of insects as animal feed, and the processing and preservation of insects and their products. It highlights the need to develop a regulatory framework to govern the use of insects for food security. And it presents case studies and examples from around the world.

Also available online: www.fao.org/docrep/018/i3253e/i3253e00.htm.



About Mediterranean forests

State of Mediterranean forests 2013. FAO & Plan Bleu. 2013. Rome, FAO.

Forest ecosystems and other wooded lands are important components of landscapes in the Mediterranean region, contributing significantly to rural development, poverty alleviation and food security. Forests and other wooded lands in the Mediterranean are sources of wood, cork, energy, food and incomes, and they provide important ecosystem services such as biodiversity conservation, soil and water protection, recreation and carbon storage.

This first report on the state of Mediterranean forests pays special attention to the vulnerability of Mediterranean forests to climate change and changes in regional demographics and lifestyles. It highlights, for example, the relationship in some parts of the region between depopulation and increased forest fires; and, in other parts, the relationship between population growth and increased deforestation.

The report reviews the goods and ecosystem and social services provided by Mediterranean forests, with special sections on cork oak forests and stone pine forests. Other sections focus on urban and peri-urban forestry; and legal, policy and institutional frameworks in the region. The report notes the urgent need for better information and tools to monitor and communicate forest changes to stakeholders across the region. In recognition of this gap, FAO intends to publish reports on the state of Mediterranean forests every five years.

Also available online: www.fao.org/docrep/017/i3226e/i3226e.pdf.

Forest farmer cooperatives in China

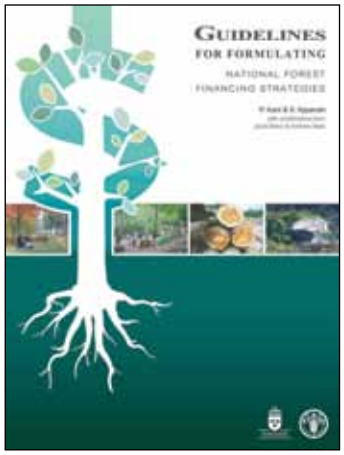
Success cases and good practices in forest farmer cooperative organizations in China. L. Wang. 2012. Rome, FAO.

To increase forest farmers' income and promote the rapid development of collective forest areas, China has being reforming its collective forest tenure system since 2003 by clarifying property rights, reducing taxes, liberalizing business operations, and regulating the transfer of rights over forest land.

Since they have been granted use rights over forest land and disposal rights over forest, farmers have been highly motivated to engage in forest production. However, the allocation of forests to individual households has also resulted in forest land fragmentation and small-scale management, which have hampered the access of individual farmers to, for example, technical services, forest fire prevention measures, pest and disease control and forest road construction. Collective management is an effective way of solving these problems. Supported by the government, various forms of forest farmer cooperative organizations (FFCOs) have been established and have increased rapidly in number.

This report collects and assesses good practices from FFCOs in China. It presents case studies on FFCOs of different types and analyses their successful experiences and good practices and their role in poverty reduction.

Also available online: www.fao.org/docrep/017/ap470e/ap470e00.pdf.

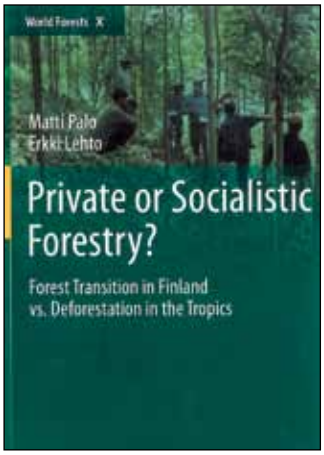


Boosting funding for the forest sector

Guidelines for formulating national forest financing strategies. P. Kant & S. Appanah, with contributions from J. Siteur & A. Steel. 2013. RAP Publication 2013/01. Bangkok, FAO Regional Office for Asia and the Pacific. ISBN 978-92-5-107476-3.

One of the major constraints to sustainable forest management is the lack of finance available to government agencies. This publication outlines the issues to be addressed to increase financing for forestry, including the roles and concerns of public institutions, how to safeguard the interests of communities, the additional sources of funding available beyond that derived from timber harvesting, and how to make the sector attractive for private-sector investment. Based on these issues, the publication presents a set of guidelines for formulating national forest financing strategies. It is hoped that this work, based mainly on developments in the Asian region, will serve to invigorate the forest sector, thereby increasing its role in economic development. The guidelines should equip countries with the means to increase their funding sources and their efforts to implement sustainable forest management.

Also available online: www.fao.org/docrep/017/i3187e/i3187e00.htm.

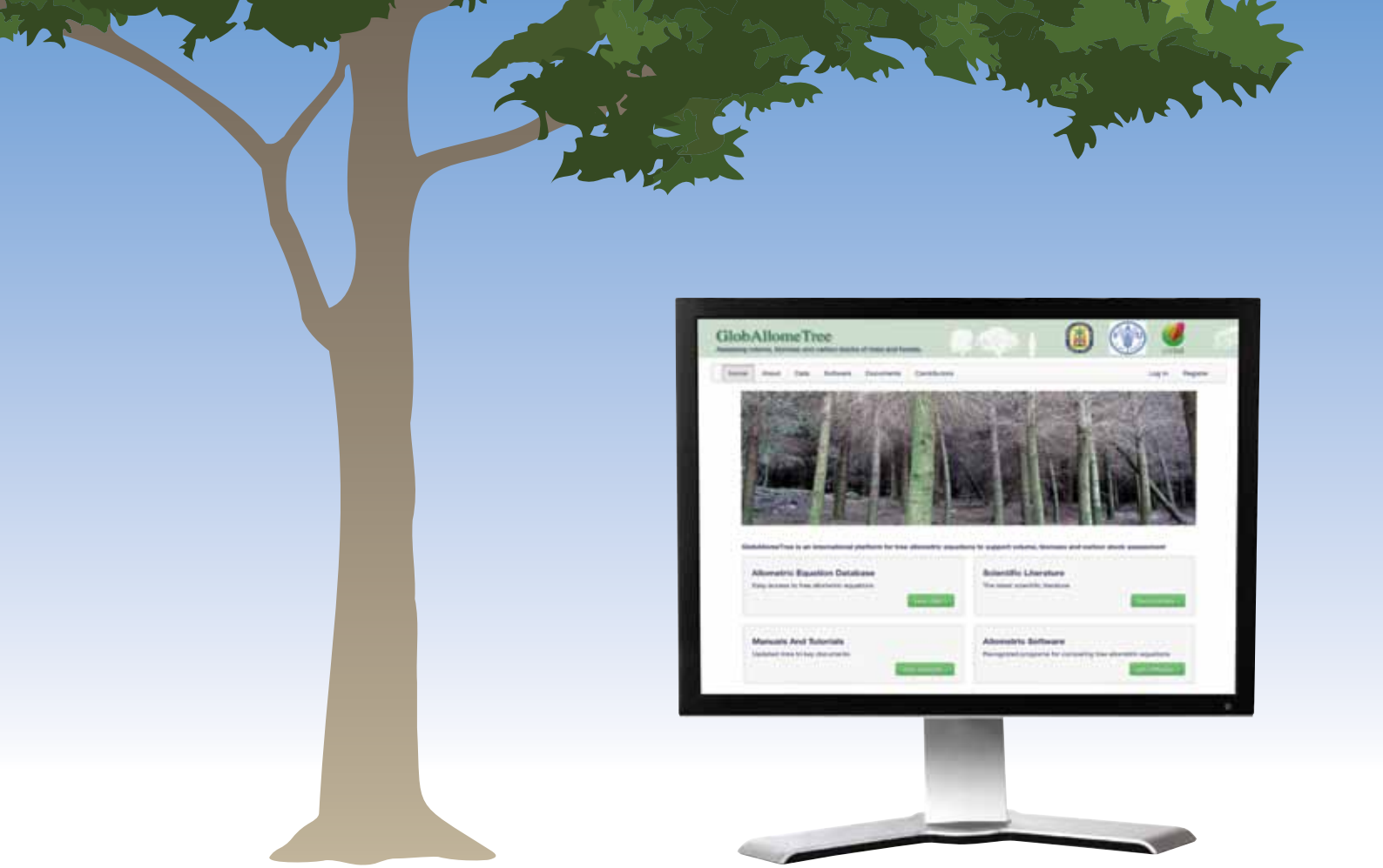


A theory on tropical deforestation

Private or socialistic forestry? Forest transition in Finland vs. deforestation in the tropics. M. Palo & E. Lehto. 2012. World Forests 10. Dordrecht, Heidelberg, London and New York, Springer. ISBN 978-90-481-3896-8.

The premise of this book is that studying the transition from deforestation to sustainable forestry in Finland in the first part of the twentieth century can provide insights into how deforestation in the tropics might be reduced in the future. Finland is the world's second-largest net exporter of forest products and also has the highest forest cover in Europe. The authors compare the underlying causes of Finland's transition with existing conditions in 74 tropical countries.

The interaction of public policies and market institutions appears to have been critical during Finland's transition. The authors suggest that private forest ownership, a continuous increase in the real value of forests, the alleviation of poverty under non-corruptive conditions, and conducive public policies were necessary preconditions for this transition. They conclude that "socialistic" forestry, which they define as "a situation where the state owns all or the majority of forests in a country, and sets stumpage prices [below] the respective market prices by administrative orders, and the forest administrators have not been [given] any financial profitability goals", along with corruption, is keeping wood prices artificially low in tropical forests.



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